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RESEARCH AND TECHNOLOGY

Technical Report AFIT TR 73-4

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UNITED STATES AIR FORCE

AIR UNIVERSITY

AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

AFIT SCHOOL OF ENGINEERING CONTRIBUTIONS TO AIR FORCE RESEARCH & TECHNOLOGY

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School of Engineering

Air Force Institute of Technology

Wright-Patterson Air Force Base, Ohio

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ABSTRACT

This report contains abstracts of Master of Science Theses, Doctoral Dissertations, and faculty publications completed during the 1972 calender year at the School of Engineering, Air Force Institute of Technology, at Wright-Patterson Air Force Base, Ohio.

PART I

INTRODUCTION

The mission of the School of Engineering is (1) to conduct accredited bachelor, master, and doctoral engineering and management programs that are particularly relevant to the needs of the Air Force; (2) to conduct jointly with Air Force Systems Command (AFSC) the Continuing Education Program for Scientists and Engineers at Wright-Patterson Air Force Base; and (3) to conduct a research and exploratory development program supplementing and supporting Air Force projects.

The primary mission of the School is education, but research is an inseparable and integral part of that activity. Since the School of Engineering offers predominantly graduate programs, strong emphasis is placed on research by both faculty and students. Most of this research is sponsored and supported by Air Force Laboratories.

The net product of research is a publication or presentation of research results. This report contains abstracts of theses, dissertations, and other research publications produced by the students and faculty of the AFIT School of Engineering during the 1972 calender year.

Most of the student abstracts list the AD number which may be used to order that particular thesis or dissertation from the Defense Documentation Center (DDC) or from the National Technical Information Services. Those without AD numbers may be obtained on interlibrary loan from the Air Force Institute of Technology Library, AFIT/LD, Wright-Patterson Air Force Base, Ohio 45433.

The abstracts of faculty publications give the Journal in which the publication appears. In many cases a copy of the article may be obtained by writing directly to the author and requesting a reprint.

Part V is an index of sponsoring organizations and Part VI is a subject index.

Additional information regarding research at the School of Engineering may be obtained by writing to the Associate Dean for Research, AFIT/EN, Wright-Patterson Air Force Base, Ohio 45433.

PART II

ABSTRACTS OF MASTER OF SCIENCE THESES

1. INVESTIGATION OF THE TRANSIENT CONDITION OF "LONG-LINE" DEPLOYMENT

Jimmie H. Butler, Maj, USAF — 64p — GA/MC/72-1
Advisor: Maj R. O. Meitz — Lab Sponsor: AMRL

In the Long-Line Loiter (LLL) maneuver, a long line is used to establish a physical linkage between the orbiting aircraft and a point on the ground. This linkage can be used to guide items down the line by parachute, or to pull items back to the aircraft. The lack of consistent and accurate techniques to deliver the end of the line to a selected target has been the main obstacle to the development of LLL systems. This thesis describes a workable solution to that problem. In the line bag delivery, one end of the long-line is tied to the aircraft, and the rest of the line is packed into a canvas bag. The line deploys from the bag as the bag drops toward the target. Tests were successfully conducted at drop airspeeds of 70 to 80 knots from altitudes up to more than 3000 feet above the target. A two-dimensional mathematical model is developed to predict the bag's trajectory from release to impact. The output of the model is compared to data gathered by using tracking cameras. This gives an indication of the validity of the predicted trajectories and the assumptions used in establishing the model. Tables are then developed to predict release points and trajectories for initial conditions besides those used in the drop tests.

2. COMPARISON OF THE PATCHED-CONIC AND LINEARIZATION METHODS IN THE SOLUTION OF THREE-BODY PROBLEMS

Thomas M. Conley, Maj, USAF — 65p — GA/MC/72-2
Advisor: Prof P. Bielkowicz — Lab Sponsor: AFIT — AD 748345

The accuracy of the patched-conic and linearization methods in predicting trajectories in a Sun-Planet system are compared. Forty-two series of trajectories were computed for forty-two different assumed initial positions and velocities. Each series consisted of an integrated three-body trajectory, a linearized trajectory and a two-body trajectory. It was shown that for all cases in which the linearization theory applied, this method was more accurate than the patched-conic method in approximating the actual three-body trajectory. It was further shown that in some cases the linearization method could be applied where the patched-conic method could not.

3. A METHOD TO COMPARE THE POTENTIAL OF A FLOWING LIQUID HYDROCARBON TO GENERATE STATIC ELECTRICITY

Valentine L. Denninger, Maj, USAF — 67p — GA/ME/72-4
Advisor: Dr. H. Wright — Lab Sponsor: AFFDL — AD 753386

This study examines static charge generation in hydrocarbon fuels during flow through pipes. Particular emphasis is placed on the effect of linear velocity, pipe diameter and length, and the liquid solid interface. A parameter was developed which may be of use to system designers as a basis for comparing static electric charge generating characteristics of various fuel-container material combinations. The parameter was first derived from theoretical considerations and then introduced into an equation which quantifies the charge carried by the liquid flowing in a pipeline. This equation became the basis for a model which defined the physical quantities which had to be obtained experimentally in order to evaluate the parameter. Laboratory scale apparatus for the measurement of conductivity and charge density in the flowing fluid

was designed, constructed and instrumented. Preliminary experimental data for JP-4 fuel confirmed that this proposed apparatus and laboratory procedure could be used to evaluate the parameter and verify its validity over a wide range of velocities and pipe lengths. A by product of this work was the development of a fully guarded parallel plate conductivity cell which indicates some improvement over other designs.

4. A SPACE RESCUE/UTILITY VEHICLE FEASIBILITY STUDY

James H. Diffendorfer, Capt, USAF — 86p — GA/MC/72-3
Advisor: Prof H. Larsen — Lab Sponsor: AFIT — AD 748346

A preliminary design study was conducted to determine the feasibility of performing space rescue, resupply, and reconnaissance with a glide-type re-entry vehicle. It was assumed the 15,000 pound rescue vehicle could be boosted to a 100 nm circular orbit by a Titan III-D launch vehicle. From this parking orbit, orbital transfer, rendezvous, and deorbit capability were determined. A re-entry trajectory analysis was performed and showed that a crossrange of 2,000 nm could be attained. Heating analysis indicated that the re-entry problem could be overcome with currently available engineering materials. Due to a relatively small onboard Δv capability, only limited use as a rescue vehicle is planned. However, utility missions, such as resupply, transportation of personnel, and reconnaissance, which do not require as strict a launch schedule as the rescue mission, can be adequately performed.

5. REDUCTION OF SULFUR DIOXIDE USING MICROWAVE DISCHARGE TECHNIQUES

Thomas D. Edmonds — 62p — GA/ME/72-3
Advisor: Maj R. Jensen — Lab Sponsor: ARL

Sulfur dioxide concentrations were reduced in a microwave discharge to investigate a possible system for industrial environmental application. An 85 watt, 2450 MHz microwave power generator and resonance cavity were used to sustain the discharge in a low pressure system. Static discharge tests were conducted with the time duration of discharge varied to determine the dependence of SO_2 reduction on molecular residence time in the discharge. The reduction of pure SO_2 in the discharge resulted in the formation of SO_3 and elemental sulfur. The net reduction of SO_2 in mixtures with selected additive gases. Carbon Dioxide (CO_2) and Ethylene (C_2H_4) were found to be effective in improving the net reduction of SO_2 in short-period (5-20 sec) discharges. Ethylene acted as an oxygen scavenger in the discharge to prevent reverse reaction formation of SO_2. Carbon dioxide, acting as an oxygen donator, reacted with SO_2 to form SO_3. Upon exposure to water vapor, SO_3 reacted to form sulfuric acid, a useful industrial by-product. A flow system was established to simulate an industrial gas flow, however realistic volumetric flow rates could not be achieved due to restraints imposed by the experimental apparatus. Pure SO_2 and an SO_2-C_2H_4 mixture were investigated. Visible quantities of sulfur products were precipitated in a cooled U-trap downstream of the discharge. Net SO_2 reduction decreased in the flow discharge as compared with short-period static discharge tests. Results of this investigation indicated that the reduction of SO_2 concentrations by means of a microwave discharge process has possibilities for industrial applications.

6. TWO-PHASE NOZZLE FLOW (GAS-SOLID)

Benjamin B. Frederick, Capt, USAF — 79p — GA/ME/72-5
Advisor: Prof Hitchcock — Lab Sponsor: AFRPL — AD 750038

A numerical method, requiring the use of a computer, is developed to determine mass flow rates in two-phase (gas-solid) rocket nozzle flow. In addition to the conservation equations of total mass, momentum, and energy, a particle energy equation and equation of motion are included in the analysis. The selection of appropriate particle drag coefficients and convective heat transfer coefficients is a primary consideration in the successful utilization of the method. A comparison is made between the non-equilibrium theory developed and equilibrium theory, which ignores the effects of particle lag. It is determined that particle lag should be considered to accurately calculate mass flow rates for two-phase flow involving particles on the order of 1μ and larger in diameter. It is also shown that an effective two-phase rocket nozzle should converge slowly from the point where A/A_t is two and less and that the divergent portion of a convergent-divergent nozzle can lose its effectiveness in two-phase flow.

7. A METHOD FOR GENERATING CLOSED-LOOP SOLUTIONS TO DIFFERENTIAL GAMES

Percy J. Gros, Jr., Capt, USAF — 68p — GA/MC/72-4
Advisor: Maj G. M. Anderson — Lab Sponsor: AFFDL — AD 748347

The zero-sum, perfect information pursuit-evasion differential game is reviewed. The purpose of this thesis is to formulate a method for generating near-optimal closed-loop solutions to these problems. The method is then applied to a number of example problems in order to check its validity. This method deals with solutions in the small and is based on updating the two-point boundary-value problem by use of the neighboring extremal path concept. The two differential game problems examined are a simple motion problem and a rocket problem. Two separate cases were studied for each problem. One was the fixed final time problem and the other was the free final time with a terminal constraint. Analysis of the results obtained, supports the feasibility of this method to provide near-optimal closed-loop solutions to differential game problems.

8. ANALYSIS OF A GRAND TOUR SUBSIDIARY MISSION

Norman H. Monson, Maj, USAF — 72p — GA/MC/72-5
Advisor: Prof P. Bielkowicz — Lab Sponsor: AFIT

In seeking to extend man's knowledge of his environment, NASA has proposed a Grand Tour of the Outer Planets for the latter half of this decade. A subsidiary mission to this multiple-planet exploration is studied as a means to increase the benefits to be derived from the Grand Tour. This mission specifically selects the planet Jupiter and the Galilean satellites as subjects for closer examination. An ecliptic plane, conic section approximation is used to determine the trajectory of the main vehicle for comparison with values published by the Jet Propulsion Laboratory, the prime facility for the project. It was found that the conic section approximation and use of a numerical solution to Kepler's Equation produced a considerably higher degree of accuracy than was originally envisioned.

Conditions required for capture of the auxiliary vehicle and subsequent planetocentric orbit are determined. An alternate method of achieving jovian orbit is discussed for comparison purposes. An evaluation of the percentage of mass of the subsidiary package required as propellant to perform the retro-thrust operation for joviocentric orbit is calculated. The velocity increment selected was somewhat higher than the minimum required, thus the mass percentage calculated, 72%, could theoretically be as low as 60%, using the minimum delta V. A lack of ephemeris data for the jovian satellites for the 1979-and-later time period mandated the development of an artificial method of determining satellite position. Circular orbits were assumed for the four Galilean moons. A 1970 epoch was calculated and used to determine the relative position of each moon at the time the subsidiary package approached the orbital radius of the satellite. For the first pass by each moon's orbital path no collisions occurred and only one satellite, VIII, was close enough to warrant investigation of perturbative effects, which, upon calculation, were determined to be negligible. The method used to compute perturbative effects of each of Jupiter's major satellites is presented. Orbital parameters for all portions of main vehicle and subsidiary mission trajectories were tabulated. In summary, the subsidiary mission not only appears to be feasible, but should provide highly favorable results in terms of previously unattainable information. This, of course, must take into consideration the weight requirements of the main vehicle, but even a modest payload would prove beneficial.

9. THE DYNAMIC RESPONSE OF FLUIDIC CIRCUITS WITH BLOCKED AND ORIFICE TERMINATED LINES

Bradley O. Montgomery, 1st Lt, USAF — 58p — GA/ME/72-2
Advisor: Dr. M. Franke — Lab Sponsor: AFFDL — AD 753384

The dynamic response of a pneumatic circuit with mean flow was investigated experimentally in the 40-1050 Hz frequency range and the results compared with theory. All cases consisted of a 0.032 in ID line with either a blocked or orifice terminated end line. The orifice sizes used were 0.0135, 0.016 and 0.020 in ID with a length of 0.062 inches. The line was tested at pressures from 1.5 to 26.0 psig. Comparison of experimental and theoretical results were made with a computer program using Nichols' equations as modified by Krishnaiyer and Lechner, with modification of attenuation for mean turbulent flow using Brown's work. A different orifice impedance model was used with mean turbulent flow than had been used with blocked or mean laminar flow. The experimental transfer gain was predicted within ±1 db of theory for a blocked line, and within ±2 db of theory for a mean laminar flow in the line. Experimental phase shift was predicted within ±15° for a blocked line, and within 30° for mean laminar flow. With mean turbulent flow in the line, the gain was predicted within ±2 db of theory for the two smallest orifices, and within ±5 db of theory for the largest orifice, while the phase shift was predicted within ±30° at frequencies less than 500 Hz, and within ±70° at frequencies greater than 500 Hz.

10. THEORETICAL STUDY OF SOLAR RADIATION EFFECTS ON THE PAGEOS SATELLITE

William B. Patterson, Capt, USAF — 68p — GA/PH/72-1
Advisor: Dr. Kissell — Lab Sponsor: ARL — AD 743618

Observation of Pageos, a 100 ft. diameter balloon satellite, indicate that driving torques must be acting on the body to cause the dynamic motions. This theoretical study tests one explanation of these torques. The proposed explanation is that solar radiation would heat the rotating satellite unevenly causing distortions in the surface. Momentum exchange between solar photons and the distorted surface would then generate the required torques. A spherical model of Pageos was found adequate to explain the torque causing rotation but totally inadequate to explain the precession torque. An oblate spheroid, which is the time averaged model of the actual shape, was then used and proved to be very successful in predicting the precession torque. The conclusions drawn from this study are that solar radiation may induce the forces necessary to explain the observed dynamical motions of Pageos.

11. FOURIER PATTERN RECOGNITION TECHNIQUES APPLIED TO TITANIUM ALLOY MICROGRAPHS

Graham L. Perry, Flt Lt, RAF — 66p — GA/EE/72-2
Advisor: Sq Ldr Gill — Lab Sponsor: AFML — AD 746720

The properties of the Fourier Transforms of Titanium alloy photomicrographs are investigated. The characteristics of the discrete Fourier Transforms are outlined, and the principles of pattern recognition by spatial filtering and matched filter correlation are discussed. The technique of data preparation is described, and the results from both spatial filtering and correlation methods are presented and discussed. The conclusion is reached that texture patterns such as metal microstructure are too noisy for successful pattern recognition by spatial filtering, but matched filter correlation techniques show some promise for accurate measurement of defined object populations in noisy samples.

12. AERODYNAMIC INTERFERENCE BETWEEN A WING AND STORE

Charles L. Turner, Capt, USAF — 59p — GA/MC/72-6
Advisor: Maj F. E. Eastep — Lab Sponsor: AFIT — AD 748348

Simplified wing and store models are used to determine the aerodynamic interference effects between an aircraft and a store carried beneath its wing. Inviscid flow characteristics are calculated and the results compared to an experimental wind tunnel study. The resulting vertical forces are comparable to those from the wind tunnel study when modeling the wing with a single horseshoe vortex. The remaining forces and moments are not predicted accurately. Methods for correcting the differences are suggested. Modeling the wing with multiple horseshoe vortices changes the side force values to values comparable to those from the wind tunnel study. This indicates that the method can be extended to correct the other forces and moments to more realistic values.

13. INVESTIGATION OF A LIQUID COOLED ANEMOMETER PROBE FOR MEASUREMENT OF HIGH TEMPERATURE GASES

Billy F. Webster, Capt, USAF — 50p — GA/ME/72-6
Advisor: Prof W. C. Elrod — Lab Sponsor: AFAPL — AD 906086

The cooled film sensor is an instrument permitting measurements in high temperature environments similar to those obtainable at normal temperatures with a hot wire anemometer. An investigation was made on Thermo Systems, Inc., HF-22 cooled heat flux probes in a premixed Fisher burner flame. The limitation of the probes both in methods of operation and accuracies are discussed. Probe sensor failure proved to be the most serious equipment problem. Schlieren technique was used to study the probe-flow field interaction and flame characteristics. Results of the Schlieren study indicated the flame to be unstable and subject to cyclical variations. Measurement of the mean temperature coefficient of resistivity of the probe sensors was found to be essential to temperature and heat flux calculations. Temperature calculations, independent of velocity and composition, are possible by using two probe sensors with different sensor temperatures; however, the burner flame proved too unstable to permit these calculations. Typical measurements of flame fronts and heat flux distribution in the combustion zone using the cooled probe are presented.

14. PURSUIT-EVASION GAMES BETWEEN TWO SPACECRAFT IN NEAR-EARTH ORBIT

Richard H. Woodward, Capt, USAF — 115p — GA/MC/72-7
Advisor: Maj G. M. Anderson — Lab Sponsor: AFFDL — AD 741454

This paper considers the problem of developing an optimum thrust angle program for a constant mass, constant thrust spacecraft which is either pursuing or being pursued by another similar spacecraft in near-earth orbit. The problem is formulated as a differential game in which the pursuer attempts to minimize the final separation distance while the evader attempts to maximize it. The problem is approached by linearizing the equations of motion about a circular reference orbit at the earth's surface. The validity of the linearized equations is verified by comparing a linearized trajectory to six non-linear trajectories. Optimum non-linear trajectories are generated by backward integration. The fixed-time and free-time two point boundary value problems are solved for the linear case. It is found that convergence to a free-time solution becomes exceedingly difficult as the terminal surface is approached. A pseudo closed loop control law is developed and tested numerically against two non-optimum evaders. The results of this control law test are promising but further tests are warranted due to the limited number of cases considered.

15. A COMPARISION OF THE EXTENDED KALMAN FILTER AND WEIGHTED LEAST SQUARES IN EARLY-ORBIT DETERMINATION

Jackson R. Ferguson, Jr., Capt, USAF — 74p — GA/EE/72S-1
Advisor: Lt Col R. A. Hannen — Lab Sponsor: AFIT — AD 741457

The problem of estimating the orbit parameters from early-orbit observations of an earth satellite is used to compare the accuracy and application of the Extended Kalman filter and the classical filtering method of Weighted Least

Squares. To obtain an absolute comparison, a true two-body, drag-free Keplerian orbit is simulated, observations are computed and contaminated with noise, and the orbit parameters estimated by each filter are compared. The accuracy of the two filters was compared using the same set of observations to determine the effect of observation truncation and initial conditions on the results. Based on this study it was concluded that the Weighted Least Squares filter and the Extended Kalman filter yield about the same accuracy in the early-orbit determination problem.

16. EFFECT OF SELECTED ALLOYING ELEMENTS ON THE ANODIC POLARIZATION BEHAVIOR OR IRON AND ALUMINUM

S. T. Ali, Sq Ldr, PAF — 51p — GAM/MC/72-1
Advisor: Capt W. B. Crow — Lab Sponsor: AFIT

Effect of selected alloying elements on the corrosion resistance of iron and aluminum in hydrogen-saturated sulphuric acid was investigated at 22 ±1°C using the anodic polarization method. The elements selected for alloying with iron were: silicon, silicon-aluminum, and silicon-aluminum-molybdenum. The elements selected for alloying with aluminum were: silicon, titanium, and silicon-magnesium. In addition, for the purposes of reference and comparison, tests were conducted on high purity iron and high purity aluminum and Duriron. For the compositions tested the corrosion resistance of iron was found to decrease with addition of silicon-aluminum and silicon-aluminum-molybdenum. Similarly, for the compositions tested, the corrosion resistance of aluminum was found to decrease with the addition of silicon, titanium, and silicon-magnesium. All of the iron-base alloys exhibited active, active-to-passive, and transpassive behavior. The aluminum-base alloys did not passivate. The limiting current densities of these alloys increased with an increase in acid concentration.

17. EXPERIMENTAL INVESTIGATION OF FLOW BEHIND STAGGERED CYLINDERS

Lauren E. Arent, Capt, USAF — 66p — GAM/AE/72-1
Advisor: Prof H. Wright — Lab Sponsor: AFAPL

An experimental study was conducted to investigate the use of correlators and Fourier analyzers in experimentally determining flow field characteristics and to compare these results with previously published data and that predicted by theory. The study was conducted in a low-turbulence wind tunnel having a maximum velocity of approximately 60 ft/sec. A 1/2 inch and 1 1/2 inch cylinder were used in the wind tunnel test section, giving an R_e range of approximately 15,000 to 45,000. Data was collected using pitot-static tubes, hot-film probes, and x-probes. The reduced data was analyzed with the aid of a correlator and Fourier analyzer. Mean velocity determination using the hot-film probes and x-probes gave accuracies comparable to that of the pitot-static tube. Mean velocity profiles obtained behind a single cylinder compare favorably with previously published data. Using the correlator and Fourier analyzer, the turbulent frequency behind the 1 1/2 inch cylinder and the 1/2 inch cylinder was found to be 103 and 309 cycles/sec, respectively, which is in agreement with that predicted by theory. The velocities and velocity fluctuations were then obtained behind the two staggered cylinders, positioned as shown in Fig. 12, using the x-probe. The correlator was again used to determine the turbulent frequencies and the wake interaction line. The effects of the wake from the 1/2 inch cylinder could be observed back to a distance of 6 cylinder diameters (1 1/2 inch cylinder diameters) behind the 1 1/2

inch cylinder. The wake from the 1 1/2 inch cylinder predominated throughout the flow field beyond that point.

18. ANALYTICAL STUDY OF CONFINED LAMINAR AND TURBULENT JET MIXING WITH BOUNDARY-LAYER GROWTH

Lynn A. Atkinson, Capt, USAF	70p	GAM/AE/72-8
Advisor: Maj S. Kitowski	Lab Sponsor: ARL	AD 742116

An analytical study of laminar and turbulent jet mixing in a straight parallel wall channel was made using three different initial velocity profiles. The system of governing equations describing the flow was solved using an implicit finite-difference technique. The governing equations were reduced to a set of linear algebraic equations that were solved simultaneously on a digital computer. The development of the axial velocity profiles and the jet mixing spreading rates for the three cases are compared. For the laminar cases, the momentum flux increased when a negative pressure gradient was present. For the turbulent jet mixing cases, the boundary-layer growth is laminar, and the analysis is restricted to the initial region.

19. A STUDY OF DETONATION PROPAGATION IN NON-STOICHIOMETRIC HYDROGEN-OXYGEN-DILUENT MIXTURES

William F. Balmanno, Capt, USAF	45p	GAM/ME/72-4
Advisor: Maj R. Jensen	Lab Sponsor: AFAPL	AD 741582

An experimental investigation of the initiation and propagation of shock induced detonation waves in non-stoichiometric hydrogen-oxygen-diluent mixtures was conducted. Equivalence ratios of 0.50, 0.75, 1.25, and 1.50 were used with 0, 50 percent, and 90 percent diluent. Diluents utilized consisted of either argon or helium. The data appeared to verify the finite reaction zone theories of Brinkley and Richardson as well as to give some information concerning critical Mach numbers and detonation onset distances. All test gases were initially at rest at 10 in. Hg. absolute pressure and approximately 293 degrees Kelvin. Compressed helium was used as the driver for the initiating shock.

20. CONDITIONAL NEARLY BEST LINEAR INVARIANT ESTIMATION OF THE SCALE AND LOCATION PARAMETERS OF THE FIRST EXTREME VALUE DISTRIBUTION

Alfred A. Boyd, Jr., Maj, USAF	515p	GAM/MA/72-1
Advisor: Prof A. Moore	Lab Sponsor: ARL	AD 743617

Conditional, nearly best, linear invariant estimators of the scale and location parameters of the first extreme value distribution are developed using order statistics. A previously untried approximate covariance is is used in place of the approximation of Gunnar Blom. Coefficients of the order statistics are calculated and tabled for sample sizes of 1 to 40. The tables include coefficients for estimation using complete samples and samples censored from above or symmetrically censored from both ends. A technique for simultaneous estimation using the conditional coefficients is described. Mean squared errors are listed for all estimators, and a comparison between these mean squared errors and the mean squared errors using the approximation of Blom is made.

21. FLOW FIELD ON THE LEE SIDE OF A DELTA WING

Robert G. Christophel, 2/LT, USAF — 54p — GAM/AE/72-6
Advisor: Maj S. Kitowski — Lab Sponsor: ARL — AD 753389

A procedure is developed which utilizes the method of characteristics to solve a portion of the flow field on the lee side of a flat plate delta wing with supersonic leading edges at angle of attack but at zero yaw. The procedure requires input conditions of a free stream Mach number M_∞, an angle of attack α, and a sweep angle χ. The procedure is applied to the following three sets of input conditions: (1) M_∞=2.96, α=14.2°, χ=45.0°; (2) M_∞=4.0, α=5.0°, χ=60.0°; (3) M_∞=3.0, α=12.0°, χ=45.0°. The resulting data is then compared to published experimental and analytical data for the same set of input conditions. The comparisons indicate that the procedure developed here may be useful in predicting the flow field in the pseudo-elliptic region and the position of the internal shock wave on the lee side of the wing.

22. INVESTIGATION OF THE EFFECT OF ALLOYING ELEMENTS ON THE CORROSION RESISTANCE OF IRON AND ALUMINUM IN SULFURIC ACID

Walter M. Coburn, LCDR, USCG — 93p — GAM/MC/72-2
Advisor: Capt W. B. Crow — Lab Sponsor: AFIT

Cathodic, galvanostatic linear-polarization curves for Fe, Al, Fe-15Si alloy, Duriron, four Fe-Al-Si alloys, four Fe-Al-Si-Mo alloys, two Al-Ti alloys, two Al-Si alloys, and two Al-Si-Mg alloys were determined in hydrogen-saturated 1N and 10N sulfuric acid at 22°C. Data were obtained within 10 mv of the steady-state corrosion potential for each specimen every 24 hours for 120 hours. Corrosion rates were determined from the polarization data using the Stern-Geary relationship and a Fortran computer program written for execution on a CDC 6600 computer. Relatively-stable corrosion rates were obtained in 120 hours. Generally, the Fe-base alloys, excluding Duriron and the Fe-15Si alloy, had a higher corrosion rate than pure Fe. Similarly, all the Al-base alloys had less corrosion resistance than pure Al.

23. DETERMINATION OF THE DRAG OF A WIND TUNNEL MODEL ENGINE DUCT BY APPLICATION OF THE MOMENTUM EQUATION

James A. Eggers, Capt, USAF — 133p — GAM/AE/72-3
Advisor: Prof H. Larsen — Lab Sponsor: AFFDL — AD 741744

A wing body model of an advanced manned interceptor was tested for subsonic force and moment data in the AFIT Five-Foot Wind Tunnel. A removable engine package contained twin internal airflow passages. Following the collection of force data both with and without the engine package, the inlets and exits of the ducts were instrumented with pressure rakes in order to determine the momentum loss and hence the drag on the model due to the internal flow. The pressure data was displayed on a vertical water-alcohol manometer board, recorded on 70mm film, and reduced by desk calculator. Axial force coefficients at various angles of attack and sideslip were computed by application of the incompressible integral momentum equation. Boundary layer theory was used to determine the drag over small portions of the duct wall surface not covered by the pressure rake procedure. The drag due to internal flow

was found to be significant and equal to 65% of the additional drag on the model when tested with the engine package. The contribution of the internal flow drag to the pitching moment was also investigated. The effect was measurable but not significant. Mass flow rates were calculated both at the inlet and exit of each duct and compared to obtain an indication of the accuracy of the instrumentation and data reduction procedure. The inlet mass flow rate was consistently high and averaged 105% of the exit value. A discussion of the experimental errors associated with the study is included.

24. LOW MACH NUMBER WIND-TUNNEL STUDY OF AN ADVANCED MANNED INTERCEPTOR

Robert M. Foley, Capt, USAF — 98p — GAM/AE/72-4
Advisor: Prof H. Larsen — Lab Sponsor: AFFDL — AD 741745

This project involved the testing of a model of a projected Advanced Manned Interceptor in the AFIT 5 Foot Wind-Tunnel at Wright-Patterson AFB, Ohio. The model was constructed by the McDonnell-Douglas Company and was a blended-body shape designed for Mach 4 cruising flight. The initial testing on the model in the supersonic range had been conducted by AEDC and low subsonic Mach number testing was required to complete the flight envelope. The test program was conducted at a Mach number of .19 at a Reynolds number of 3.6×10^6. Basic performance parameters were recorded on IBM cards and the data was reduced with the FDL-8 data reduction program from the Air Force Flight Dynamics Laboratory. The reduced data supplied the parameters to determine basic lift, drag, and pitching moment characteristics of the model as well as thirteen of the static stability derivatives. This project gave an insight into the low Mach number characteristics of a blended-body shape designed for Mach 4 cruising flight.

25. A MONTE CARLO TECHNIQUE USING COMPONENT FAILURE TEST DATA TO APPROXIMATE RELIABILITY CONFIDENCE LIMITS OF SYSTEMS WITH COMPONENTS CHARACTERIZED BY THE WEIBULL DISTRIBUTION

Robert G. Lannon, Capt, USAF — 53p — GAM/MA/72-2
Advisor: Prof A. Moore — Lab Sponsor: AFIT — AD 743633

This paper develops a Monte Carlo technique which, with a digital computer, determines confidence limits for system reliability of complex systems containing components characterized by the Weibull distribution. The component distribution shape and scale parameters are estimated by the method of maximum likelihood from component failure times while the location parameter is assumed known. The asymptotic distribution of these maximum likelihood estimators and a Monte Carlo simulation are used to determine confidence limits on system reliability. As an example, confidence limits are calculated for two systems of up to eight components in combinations of series and parallel configurations using 99, 499, 999, and 2999 simulations. Accuracy of the confidence limits is found to be satisfactory after being checked by a method using a double Monte Carlo technique.

26. INVESTIGATION OF STABILITY AND CONTROL CHARACTERISTICS OF AC130 LINEAR MODELS

Robert G. Lorenz, Capt, USAF — 76p — GAM/AE/72-5
Advisor: Lt Col Thompson — Lab Sponsor: AFFDL — AD 753388

Mathematical models of the AC130A and AC130E aircraft are proposed. The models are developed from linearized equations and are referred to trim conditions of level turning flight. The proposed AC130E model is compared to an existing model to ascertain whether any significant differences exist between the two. A qualitative comparison is conducted by investigating each model's response to control deflections. The proposed AC130A model is used to predict general trends and probable values for stability derivatives and selected mode parameters over an extensive flight envelope. The proposed AC130E model exhibited increased phugoid damping, and its dutch roll oscillations and divergent modes were generally weaker than those of the existing model. Short period characteristics were identical. The data compiled to estimate trends and values of stability parameters for the AC130A aircraft produced no unusual results.

27. ANALYSIS OF BEAM BENDING EXPERIMENTS ON OFF-AXIS LAMINATED COMPOSITES

Alexander Mair, Capt, USAF — 82p — GAM/MC/72-3
Advisor: Maj R. O. Meitz — Lab Sponsor: AFML

An experimental investigation was conducted on the effect of shear coupling on the results of flexure tests performed on off-axis laminated composite beams. Tests were performed on Scotchply and graphite-epoxy specimens of three different angle orientations. Other factors considered were: length to thickness and length to width ratios, free edge effect, and shear deformation. An equation for expressing the effects of shear deformation was derived. The results of the flexure tests were compared to values predicted by equations derived by reducing laminated plate equations to equations applicable to narrow beams. It was found that shear coupling does have a significant effect on the bending modulus. It was further revealed that all of the factors listed above did influence the results of the flexure experiments.

28. AN APPLICATION OF THE METHOD OF LINES TO THE TRANSONIC AIRFOIL PROBLEM

John R. McCracken, 2/Lt, USAF — 52p — GAM/AE/72-7
Advisor: Capt S. Koob — Lab Sponsor: AFIT — AD 753390

This study presents the development and evaluation of a numerical solution to the transonic airfoil problem. For this initial investigation of the solution method the scope is restricted to symmetrical airfoils at zero incidence angle in an inviscid flow field. The small perturbation relationship and the irrotationality condition are selected for the set of governing equations and after limiting their domains by a coordinate transformation, the set is reduced to a system of ordinary differential equations by the method of lines. Solutions to this system are then evaluated by comparison against experimental data on a subcritical, critical, and supercritical airfoil and against the exact solutions to the subsonic and supersonic infinite wavy wall. It is concluded that the proposed solution technique, if given the correct initial conditions, can produce extremely accurate results with very short computation time and storage space.

29. VIBRATION ANALYSIS OF PIEZOELECTRIC TRANSDUCERS

Carl W. Rule, Capt, USAF — 97p — GAM/MC/72-4
Advisor: Prof P. Nemergut — Lab Sponsor: AFIT

The purpose of this study was to theoretically determine the displacements and the distribution of stresses in a hollow, thick-walled, transversely isotropic, piezoelectric cylinder which was subjected to an electromotive driving force in the axial direction. General theory was developed including the equations of motion, strain, and of state. A power series solution was programmed for the CDC 6600 computer system using the Fortran language, and the first three modes of vibration were analyzed for three separate PZT-4 cylinders. The maximum displacements were of the order of microinches near resonance frequencies when driven by 400 volts. All points on a cross section moved uniformly in the axial direction with only slight variations in wall thickness. Stresses were observed to be a function of radial position; maximum stresses occurred near the mean diameter. Shear stresses were of significant value and determined to be worthy of consideration in transducer design.

30. AN ATTEMPT TO MODEL THE FUN INTERNAL BALLISTICS PROBLEM

James F. Setchell, Jr., Capt, USAF — 74p — GAM/ME/72-2
Advisor: Prof J. Hitchcock — Lab Sponsor: AFRPL — AD 741749

An attempt is made to model the internal ballistics process of a powder-burning gun by replacing the actual internal ballistics process with an incremental sequence of phases. These phases are a constant-volume energy transfer phase, a shell motion and finite-amplitude wave propagation phase, a propellant motion phase, and a gas expansion and mass transfer phase. The model permits consideration of a chambered, powder-burning gun problem with unspecified pressure, density, velocity, temperature, and propellant distributions. The method of solution shows promise, but useful results have not been attained to date.

31. CONDITIONAL BEST LINEAR INVARIANT ESTIMATION OF THE LOCATION AND SCALE PARAMETERS OF THE CAUCHY DISTRIBUTION BY THE USE OF ORDER STATISTICS

Ralph M. Spory, Jr., Capt, USAF — 97p — GAM/MA/72-3
Advisor: Prof A. Moore — Lab Sponsor: AFIT — AD 744693

Linear coefficients which can be applied to sample data from a Cauchy distribution to obtain estimates of the location and scale parameters are developed and tabled. Several previous works have presented such tables for nearly best linear unbiased estimation and best linear unbiased estimation of the parameters. The estimates developed in this paper are best in the sense that they possess minimum mean square error. By using exact values of the means, variances, and covariances of the Cauchy standardized order statistics and minimizing the mean square error function, matrix equations are developed and solved to obtain the required coefficients. These coefficients and values of the MSE are tabled for minimally censored sample sizes of 5 to 20 and for samples which have been additionally censored from above and symmetrically. Procedures for using the tables and several illustrative calculations demonstrate the simplicity of this estimation technique. The Fortran programs required to calculate and table the above values are included in Appendix C.

32. EXPERIMENTAL STUDY OF THE EFFECT OF FLAP SETBACK AND GAS TEMPERATURE ON THE LIFT OF A JET DEFLECTION FLAP

Harold M. Stewart, Maj, USAF — 90p — GAM/ME/72-6
Advisor: Dr. A. Shine — Lab Sponsor: AFFDL — AD 741583

An investigation was conducted on the effect of setback, combined with elevated gas temperatures, on Coanda attachment to a curved plate. The tests used a rectangular convergent nozzle of 0.2 in width. Setback distances ranged from 0.0 to 0.35 in. Chamber pressures used were 15.0, 20.0, 25.0, and 30.0 in Hg gage. Chamber temperatures ranged from ambient to 1100 F. Turning efficiency and surface pressure distribution were analyzed. It was found that at higher chamber pressures, setback resulted in lower turning efficiencies versus improved efficiencies at lowered pressures. Flow impingement on deflection surface caused hot spots. Air flow patterns over a flap on a 1/6th scale propulsive wing model were analyzed. The wing was designed by LTV Aerospace Corporation. Nonuniform air flow was observed which probably contributed to flow separation. The separation was observed during previous wind tunnel tests.

33. A STUDY OF NONEQUILIBRIUM EFFECTS ON IGNITION DELAY IN A SUPERSONIC AIRSTREAM

Donald M. Teasdale, 1/Lt, USAF — 57p — GAM/ME/72-1
Advisor: Maj R. Jensen — Lab Sponsor: AFAPL — AD 741581

The purpose of this study was to determine analytically the effects of water vapor on the ignition delay process in the burning of gaseous hydrogen in a supersonic flowing vitiated airstream. A low temperature (950 - 1000°K) regime was used so the reaction rates would be dominate over the diffusion rates. In this study two chemical kinetic computer programs were used to analytically predict the ignition delay times using the inputs from seven vitiated-air heater experimental investigative conditions. The analytically calculated ignition delay times, for the seven comparitive clean-air and vitiated-air cases, were then compared to the experimental results to determine the effects of water vapor on the ignition delay time. It was found that the water vapor shortened the ignition delay time in the temperature regime of this investigation.

34. AN ANALYSIS OF THE FLOW FIELD AROUND A 2-D BODY OF ARBITRARY SHAPE

Ellie B. Underwood, Jr., Capt, USAF — 77p — GAM/AM/72-2
Advisor: Capt S. Koob — Lab Sponsor: AFIT

An analytical study of the two-dimensional viscous, incompressible steady flow over an airfoil of arbitrary shape was made. Theodorsen's method was used to analyze the potential flow around the airfoil, providing edge velocities for the boundary layer equations, which were then solved by the Karman-Pohlhausen method. The resulting boundary layer displacement thickness was then added to the original airfoil shape to obtain a better potential flow solution. Iteration was continued in this manner until the desired accuracy was obtained. A computer program was written to effect this airfoil analysis technique. Potential flow surface velocity distribution, angle of attack at zero lift, and wall shearing stress were shown to agree well with results of other investigators.

35. INVESTIGATION OF THE HOT CORROSION MECHANISM IN NICKEL - 8 CHROMIUM - 6 ALUMINUM

Nathan J. Adams, Jr., Capt, USAF — 50p — GAW/MC/72-1
Advisor: Capt W. B. Crow — Lab Sponsor: ARL — AD 748349

The mechanism of hot corrosion in a nickel-chromium0aluminum alloy was investigated. The effects of three sodium salts (sulfate, carbonate, and nitrate) were studied at 1000°C in 150 torr oxygen; additionally, tests were conducted with sodium sulfate at 900°C in oxygen and at 1000°C in argon. Continuous gravimetric data were taken for each experiment; corroded specimens were analyzed using X-ray diffraction, metallographic, and electron microprobe techniques. The hot corrosion mechanism involves a sequence of events: formation of an oxide layer, formation of subsurface chromium sulfides, dissolution of the protective oxide scale, and oxidation of the sulfides and the chromium-depleted substrate. The role of sulfur in the hot corrosion process is the depletion of chromium in the alloy; the alloy is thus susceptible to increased oxidation.

36. EXPERIMENTAL DETERMINATION OF AERODYNAMIC STABILITY DERIVATIVES THROUGH FREE ANGULAR OSCILLATION WIND TUNNEL TESTS

Clinton D. Allison, 1/Lt, USAF — 39p — GAW/MC/72-2
Advisor: Prof H. C. Larsen — Lab Sponsor: AFATL

Free-oscillation wind tunnel tests were run on a 5% scale model with one degree of freedom motion in pitch. The object was to determine the possibility of extracting the pitching moment stability coefficient, C_{m_α}, and the pitch damping moment stability coefficient, $C_{m_q} + C_{m_\alpha}$, from films of the motion. The center of rotation of the model was moved fore and aft of the model center of gravity and runs were made at dynamic pressures of 25psf and 50psf. It was determined that the coefficients could be evaluated in this manner, but that extreme care must be exercised to eliminate nonaerodynamic friction in the tunnel support system.

37. AN EXPERIMENTAL STUDY OF ATTENUATION OF SHOCK WAVES IN THREE MIXTURES

James W. Clark, Jr., Maj, USAF — 82p — GAW/MC/72-3
Advisor: Prof P. J. Torvik — Lab Sponsor: AFFDL — AD 748350

Two experiments were conducted to determine the effects of adding a gas to a foam-water mixture to increase the attenuation of shock waves caused by hydraulic ram. In each experiment three target materials were impacted: water, water and reticulated polyurethane foam, and water and Pneumacel. Pneumacel is a DuPont tradenamed product consisting of Dacron fibers inflated with 12% by weight Freon gas. In the first experiment, plane (one dimensional) shock waves were generated by impacting the target materials with a flat aluminum disc. In the second experiment, 1/2 in. spheres were fired into the target materials. In each experiment pressures were measured at various depths in each mixture for several impact velocities. An increase in attenuation of shock waves was observed in both experiments when foam was added to the water. Most of this increase was attributed to the presence of approximately 6% by volume of air present in the water-foam mixture. Significantly reduced pressures and increased attenuation of shock waves were observed in the water-Pneumacel (foam and gas) experiments. The results are compared to applicable theoretical models.

38. A GRADIENT TECHNIQUE FOR DETERMINING IMPROVED AIRCRAFT TRAJECTORIES FOR REDUCING AIRCRAFT PROBABILITY OF KILL TO ANTI-AIRCRAFT GUN FIRE

Cloyd L. Cooper, Jr., Capt, USAF — 58p — GAW/MC/72-4
Advisor: Maj G. M. Anderson — Lab Sponsor: ASD — AD 741373

The problem is to develop a technique for predicting improved aircraft flight paths that simultaneously: (1) reduce the probability of the aircraft being killed by anti-aircraft gun (AAA) fire, and (2) fly the aircraft to certain specified position and velocity vectors, both in and out of gun range. This study develops and demonstrates a gradient minimization technique called OPTAAA for solving this problem. OPTAAA utilizes the SIMFIND1 AAA attrition model, written by the Institute for Defense Analyses, as a subroutine for computing the aircraft probability of kill. OPTAAA is applied to three problems. One of the problems utilizes two-dimensional aircraft trajectories and results in a 39.7 percent reduction in probability of kill. The second and third problems utilize three-dimensional aircraft trajectories and result in a 17.7 percent and 41.5 percent reduction, respectively, in probability of kill.

39. ISO-DAMAGE CURVES FOR A SIMPLY SUPPORTED BEAM

William E. Danner, 2/Lt, USAF — 47p — GAW/MC/72-5
Advisor: Dr. D. W. Breuer — Lab Sponsor: AFFDL — AD 737362

This paper presents a theoretical development of iso-damage curves for elastic-perfectly plastic simply supported beams which are loaded by blast waves. A blast wave is modeled as a simple exponentially decaying forcing function. The development assumes the beam responds in its normal modes of vibration during the elastic phase of the response and as a mechanism after the elastic limit is reached. The use of iso-damage curves is illustrated. Theoretical predictions of plastic deformation of a simply supported beam computed using the first mode approximation and those computed using the first and the third mode approximation bracket the experimental data of Baker.

40. FLUID RESPONSE TO PLATE IMPACT

John R. Easter, Capt, USAF — 70p — GAW/MC/72-6
Advisor: Prof P. J. Torvik — Lab Sponsor: AFFDL — AD 748340

A theoretical means of obtaining the pressure field between two infinite elastic plates one of which is excited by periodic pulses applied at a point is developed. The Timoshenko-Mindlin plate equation, which includes the effects of rotatory inertia and shear deformation, is used to describe the motion of each of the plates. The fluid between the plates is assumed to be compressible and inviscid and is described by the fluid wave equation. The solution is obtained by use of Hankel transforms. The inverse Hankel transform is obtained by numerical integration and by an approximation using the method of steepest descent. Satisfactory agreement between the two sets of results were found for pulse lengths on the order of ten microseconds.

41. PRELIMINARY AERODYNAMIC DESIGN OF A MODULAR BOMB

Gary W. Findlay, Maj, USAF — 90p — GAW/MC/72-7
Advisor: Maj F. Eastep — Lab Sponsor: AFATL

An evaluation of the subsonic longitudinal stability and control characteristics was used to develop a preliminary configuration design of a modular bomb with an 800 lb warhead. The equations of longitudinal motion for a controls fixed configuration were solved for 33 configurations and the three configurations with the best stability characteristics were selected for further evaluation. The weight and center of gravity location of the three final configurations were varied; the stability characteristics of each were analyzed for various conditions; and a final configuration was selected for the control analysis. The velocity response, angle of attack response, and pitch response to an elevator pulse, to a constant elevator deflection, and to a periodic elevator deflection were determined for the final configuration. The study was concluded with computations of the elevator deflection required per g; the force exerted on the elevator per g; the maximum vertical gust which could be controlled by the elevator; and the preset elevator deflection to produce a zero pitching moment at bomb release.

42. MAXIMUM LAUNCH RANGE FOR AN AIR-TO-AIR MISSILE EMPLOYING PROPORTIONAL NAVIGATION FOR GUIDANCE

James R. Garey, Lt Col, USAF — 104p — GAW/MC/72-8
Advisor: Maj G. Anderson — Lab Sponsor: ASD

Necessary conditions for the optimal control of burning rate upon the maximization of launch range are developed and applied to a simple model of a tactical air-to-air missile employing proportional navigation for guidance. The necessary conditions imply that in general a maximum thrust arc, followed by a singular thrust arc, and finally by a zero thrust arc in maximum launch range trajectories. The two point boundary problem is completely solved for the one-dimensional intercept problem. However, difficulty in obtaining a solution to the two-dimensional intercept problem was encountered due to instability in the missile trajectory.

43. THE EFFECT OF TARGET MANEUVERING ON KILL PROBABILITY IN AIR-TO-AIR GUNNERY

Richard E. Guild, Maj, USAF — GAW/MC/72-9
Advisor: Maj R. Meitz — Lab Sponsor: AFATL — AD 903418

A study was made to determine the effect of target maneuvering during projectile flight time on kill probability in air-to-air gunnery. The effect of target uncertainty was analyzed by comparing kill probabilities for a specified non-maneuvering target with kill probabilities for an average defensively maneuvering target. The kill probability of the average maneuvering target was defined as the average kill probability for the specified target when performing a negative-g jink, hard turn, and break. The kill probabilities were calculated using a mathematical model to approximate the gunnery attack. Firing condition were parametrically varied from 500 feet to 3000 feet line of sight range and zero to 45 degrees angle-off. Two dissimilar rapid firing cannons are compared in the analysis. Kill probability was based on trackshoot aiming when the attacker's g-loading to establish lead for target motion

was 5.6 g's or less, and snapshoot aiming when greater. It was concluded that target uncertainty has no effect on kill probability when the time of flight is less than .5 seconds, but that it significantly affects kill probability when the time of flight is greater than .8 seconds. It was also concluded, that for air-to-air gunnery, the ballistic dispersion of rapid firing cannons should be such that 80 percent of the rounds are within a circle of nine to ten mils diameter.

44. HIGH TEMPERATURE OXIDATION OF SILICON CARBIDE

Warren J. Miller, 1/Lt, USAF — 55p — GAW/MC/72-11
Advisor: Capt W. B. Crow — Lab Sponsor: ARL — AD 748351

Thermogravimetric measurements were made for the oxidation of hot pressed silicon carbide at an oxygen pressure of 150 torr and at temperatures from 1300°C to 1600°C. Oxidized samples were then analyzed using X-ray, metallograph, and electron probe techniques. The oxidation rate was found to increase with temperature. A sharp increase in the oxidation rate found between 1400°C and 1500°C was attributed to the presence of water vapor. The products of oxidation were a carbon oxide and a protective layer of silica. The silica was primarily amorphous with some tridymite or α-cristobalite.

45. CRITICAL COLD-WORK FOR GRAIN COARSENING OF EQUIAXED ALPHA Ti-5Al-2.5Sn

Thomas K. Moore, Capt, USAF — 57p — GAW/MC/72-12
Advisor: Maj C. Stuber — Lab Sponsor: AFML — AD 748352

An investigation was conducted on grain coarsening of a Ti-5Al-2.5Sn titanium alloy heated at 1144°K (1600°F) for one hour after plastic tensile deformation. Cylindrical tensile test specimens were pulled up to 13% elongation to determine the linear plastic deformation and work energy input necessary to cause maximum grain coarsening after heat treatment. The influence of strain, deformation temperature, strain rate, and grain size on grain coarsening was studied. For this purpose specimens with an initial average grain diameter of 11.8 μm were deformed with a strain rate of 6.67×10^{-4} s^{-1} at five temperatures (77, 298, 367, 478, and 598°K) and with two additional strain rates (2.67×10^{-2} s^{-1} and 2.67×10^{-5} s^{-1}) at 298°K. In addition, specimens with initial average grain diameters of 10.7 μm and 22.5 μm were deformed with a strain rate of 6.67×10^{-4} s^{-1} at 298°K. Grain coarsening was ascertained in all specimens except those from material with an original grain size diameter of 22.5 μm. In the small grain material at elongations and work inputs less than critical values, no significant change from the original grain size was noted. When the critical amount was exceeded, the grain size increased abruptly, becoming 2 to 2 1/2 times its original size. As elongation and work input exceeded the critical values, the grain size decreased. Both the critical elongation and work energy input varied with the deformation temperature.

46. AN APPROXIMATE VELOCITY POTENTIAL FOR A SLENDER BODY OF ELLIPTIC CROSS-SECTION IN AN IDEAL AIR STREAM

Michael D. Pavich, Maj, USAF — GAW/MC/72-13
Advisor: Maj F. Eastep — Lab Sponsor: AFIT — AD 748353

This study is an analysis to examine the validity of a small perturbation approximation technique for determining the aerodynamic forces of a slender

body of noncircular cross-section. The approach used was to apply the technique to a problem that could also be solved exactly. The problem chosen was a corrugated cylinder of infinite length and elliptic cross-section in an irrotational ideal air stream. An approximate disturbance velocity potential for a body of elliptic cross-section is found by introducing a small perturbation parameter into the equation representing the surface of a circular corrugated cylinder. The governing equation and boundary conditions for a corrugated elliptic cylinder are then transferred to elliptic coordinates and solved exactly by separating the variables. The two solutions are then compared graphically for varying eccentricities to establish the point at which the approximation no longer produces values that are acceptable for engineering use. It is found that the first order approximation provides values for the disturbance velocity potential on the body surface that are within 5% of the exact solution, up to eccentricities of about 0.6. It is also shown that as the distance from the surface increases the comparisons are good to eccentricities of less than .8. Comments are given on improving the accuracy and extending the range of the approximation, and recommendations are made for further study.

47. THE MINIMUM-TIME TO TURN PROBLEM FOR A HIGH THRUST TO WEIGHT RATIO AIRCRAFT

Larry J. Roach, 1/Lt, USAF — 68p — GAW/MC/72-14
Advisor: Maj G. Anderson — Lab Sponsor: AFFDL — AD 748354

Optimal control theory is used to determine open-loop control laws for thrust, coefficient of lift, and bank angle for minimum time maneuvers for high thrust-to-weight ratio aircraft. In obtaining these control laws, an aircraft mathematical model is used which includes constraints on thrust, coefficient of lift, and on the aircraft load factor. Numerical results are discussed for two maneuver problems which are stated as minimum-time turns from specified initial conditions to the following terminal conditions: (1) only heading angle specified; (2) heading angle and velocity specified. For both Problem 1 and Problem 2 the numerical results show that variable bank angle, variable altitude trajectories are minimizing. No conclusion is reached regarding the thrust and coefficient of lift programs for Problem 2, for Problem 1, the numerical results indicated that maximum thrust and maximum coefficient of lift are optimal for velocities below the corner velocity, and that minimum thrust and maximum load factor are optimal for velocities above the corner velocity.

48. APPROXIMATE FIRST NATURAL FREQUENCIES OF UNIFORM THIN PLATES WITH SLIGHTLY NONCIRCULAR BOUNDARIES

Robert L. Staloch, Capt, USAF — 83p — GAW/MC/72-15
Advisor: Maj F. Eastep — Lab Sponsor: AFFDL — AD 748355

An attempt was made to obtain first natural frequencies of vibration of slightly noncircular plates by regular perturbation theory. The method of this study assumed a three term asymptotic series to represent the mode shape of a freely vibrating plate. The first term was recognized

to be the mode shape of an equivalent circular plate. The second and third terms represented approximations, in decreasing significance, of higher mode shapes of a circular plate. Boundaries of the non-circular plate were represented by the first few significant terms of a Fourier series. Restraint conditions at the plate boundaries were specified and the assumed mode shape was satisfied at the boundary given by the Fourier series. The Taylor series expansion expressed implicit parameters explicitly in the final equations. Relationships between modal amplitudes were expressed by Cramer's rule from the set of angular dependent equations. The characteristic determinant was obtained by selecting only those terms from the boundary equations that were angular independent. Characteristic equations were found for various noncircular plates. Within limits of noncircularity, excellent agreement was found between results of this study and the results of experiment and previously known approximate methods. For example, this study found a first natural frequency of a square plate that differed less than 0.5 percent from the previously known solution.

49. AIRBORNE INTERCEPT RADAR INSTALLATION IN A LIGHTWEIGHT FIGHTER

Mack Thies, Maj, USAF — 82p — GAW/MC/72-16
Advisor: Prof H. C. Larsen — Lab Sponsor: AFIT

This report examines the impact of adding an air to air intercept radar fire control system and all-weather missiles to a proposed design for a lightweight fighter. The effect of adding these systems on the dogfight performance of the aircraft are examined using energy-maneuverability diagrams. Performance of the aircraft against current and projected threats are discussed. Finally, conclusions and recommendations on the appropriateness of this aircraft design to the needs of the AF are presented.

50. A NUMERICAL MODEL OF SURFACE RECESSION PHENOMENA OF METALS SUBJECTED TO LASER RADIATION IN AN AERODYNAMIC ENVIRONMENT

Richard G. Wigglesworth, Maj, USAF — 146p — GAW/MC/72-17
Lab Sponsor: AFWL

A two-dimensional numerical model of the surface recession dynamics and transient heating of metal plates simultaneously subjected to high intensity laser radiation and aerodynamic frictional forces is developed. The model employs heat and force balance calculations over successive finite time increments on an array of finite elements constructed within the plate's cross-sectional profile lying parallel to the wind vector and bisecting the laser beam spot. A computer program of the model in FORTRAN Extended is provided. The model, exercised at various mach numbers, was found to give results consistent with simplified limiting cases of instantaneous melt removal. Melt-through times for 0.05, 0.10, and 0.20 centimeter thick sheets of aluminum, magnesium, stainless steel, and titanium absorbing 1 and 10 kilowatts of power over spots of 1 cm^2 and 10 cm^2 at mach numbers ranging from 0.0 to 4.0 are presented.

51. FRENCH-ENGLISH MACHINE TRANSLATION - GENERAL PRELIMINARIES AND LEXICAL ROUTINE DEVELOPMENT

Lee F. Aldridge, 1/Lt, USAF — 116p — GE/EE/72-1
Advisor: Dr. M. Kabrisky — Lab Sponsor: FTD — AD 741259

A report on the continuing research aimed at the development of a French to English machine translation system based on modification of the operational SYSTRAN Russian to English MT System. SYSTRAN is summarily discussed in the introductory chapters. The main body of the report concerns the development of computer programs to solve the problems caused by numerous multiple-meaning French words. The actual flowcharts and programs which were developed, plus a test translation, are contained in the appendices.

52. AN INVESTIGATION INTO THE USE OF SPATIALLY-FILTERED FOURIER TRANSFORMS TO CLASSIFY MAMMARY LESIONS

Larry L. Bowman, Maj, USAF — 58p — GE/EE/72-2
Jerold V. Everard, Capt, USAF — Lab Sponsor: AMRL — AD 742429
Advisor: Dr. M. Kabrisky

Lesions of the female breast are analyzed using one- and two- dimensional Fourier transform techniques and power spectrum analysis. Attempts are made to perform a computer classification between lesioned and non-lesioned breast tissue. Additionally, attempts are made to ascertain the inter-class difference in Fourier space between lesioned breast tissue which would enable accurate computer classification of benign and malignant lesions. Low frequency spatial filtering techniques are used in conjunction with the Euclidean distance and a nearest neighbor clustering metric in an attempt to accurately separate the various classes. Some success was observed when using the lower frequencies generated by the one-dimensional Fourier transform to separate benign and malignant breast tissue. However, no success was achieved when using two-dimensional Fourier transform and power spectrum analysis.

53. DESIGN AND FABRICATION OF A CONTROL CONSOLE FOR THE MINUTEMAN I D17B COMPUTER

Robert C. Brady, Maj, USAF — 112p — GE/EE/72-3
Charlie D. Huskey, Capt, USAF — Lab Sponsor: AFLC — AD 742437
Advisor: Dr. G. Lamont

This thesis describes the design and fabrication of a control console for the Minuteman I D17B computer. The console was built so that the D17B could be used in a laboratory for reutilization study and digital experimentation. Circuit design procedures, theory of operation, and detailed schematic diagrams are provided. Also, operating instructions, maintenance check-out procedures, wire lists, signal specifications, and a parts list are included. The information necessary to operate and maintain the D17B Computer Control Console is provided in this thesis. It can also serve as engineering data documentation to others interested in a similar project.

54. ANALYSIS OF AN OPTIMAL DETECTOR FOR A SIGNAL WITH TIME-VARYING CARRIER PHASE

John W. Briggs, 1/Lt, USAF — 56p — GE/EE/72-4
Advisor: Lt Hatsell — Lab Sponsor: AFIT

Performance characteristics of an optimal detector for a signal with time-varying carrier phase are obtained. A digital computer program is developed to simulate the detector model. Receiver Operating Characteristics are used to evaluate the performance. It was found that for this detector model a phase angle known to within thirty-eight degrees, approximately, corresponds to a phase known exactly. Performance curves are also shown for several cases of noise levels and phase knowledge.

55. MINICOMPUTER EMULATOR

Edgar E. Burkett, Jr., Capt, USAF — 346p — GE/EE/72-5
Advisor: Dr. G. Lamont — Lab Sponsor: AFAL

A computer program was developed to emulate the operation of the Digital Equipment Corporation's PDP-12 minicomputer at the register transfer level. The program is written in FORTRAN IV Extended and is designed to be used interactively from teletypes under control of the CDC 6600 INTERCOM System. The program executes the PDP-8 subset of the PDP-12 instruction set with a teletype input/output interface. The emulator assumes a PDP-12 memory size of 16,384 words and the Extended Arithmetic Element option is included. The PDP-12 front console controls and displays are simulated. The PDP-12 switch labels are used as command inputs to the program to control program execution. PDP-12 programs are loaded in octal form using appropriate commands entered at the teletype. Other commands are included to facilitate the operation of the program and control of the INTERCOM system. Example programs and printouts are included as well as a complete User's Manual for the program.

56. DESIGN AND SIMULATION OF A SMALL GENERAL-PURPOSE DIGITAL COMPUTER

Leroy B. Chamberlain, Jr., Capt, USAF — 285p — GE/EE/72-6
Advisor: Dr. G. Lamont — Lab Sponsor: AFAL

A small, general-purpose digital computer was designed and then simulated by a FORTRAN IV program. The final computer design was specified by logic equations. The resulting computer has a 128 word core memory and uses a 12 bit word. It can execute 20 instructions including fixed point multiplication and division. Extra instructions can be added with slight modification for a total of 32 instructions. The computer logic was simulated by a FORTRAN IV program. The Boolean logic operations were simulated by the FORTRAN IV logic operators, .AND., .OR. and .NOT. . The purpose of the simulation program is to provide students of computer design with a software instructional computer.

57. SOFTWARE SIMULATION OF THE MINUTEMAN D17B COMPUTER

Bruce Chatterton, Capt, USAF — 155p — GE/EE/72-7
Advisor: Dr. G. Lamont — Lab Sponsor: AFAL — AD 742965

A software program has been written which simulates the functions of the Minuteman D17B computer at the register transfer level. The simulation

program is written in the FORTRAN Extended Language to be used on the Intercom System (teletype) of a CDC 6600 computer system. The simulation program consists of a main program and eight subroutines. A programming language for the D17B simulation program was formed which contains numbers and load codes, switches, and miscellaneous commands. Example programs run on the simulated computer have been included to show the types of output available.

58. PIEZOELECTRIC-PIEZORESISTIVE COUPLED STRAIN TRANSDUCER

Gerald L. Cline, 1/Lt, USAF — 106p — GE/EE/72-8
Advisor: Prof J. Lubelfeld — Lab Sponsor: RADC — AD 743318

This study explores the possibility of using a complementary coupling of the piezoresistive and piezoelectric effects to produce a very sensitive strain transducer. The piezoresistive effect of Si is combined with the piezoelectric effect of a ZnO thin-film in a new type of strain sensor, called the PZER. The polarization field of the ZnO activation layer changes the carrier density in the piezoresistive element. The PZER has up to 280% of the strain sensitivity of a normal piezoresistive strain transducer. The theory, fabrication, and evaluation of the PZER's is thoroughly discussed.

59. AN AUTOMATIC SPEECH RECOGNITION SYSTEM USING A VOCODER INPUT

Keith G. Dailey, Lt Col, USAF — 78p — GE/GGC/EE/72-18
Frankie S. Sutton, 2/Lt, USAF — Lab Sponsor: AMRL — AD 742441
Advisor: Dr. M. Kabrisky

Speech recognition is accomplished by off-line machine processes based on visual pattern recognition techniques. The fundamental system uses digitized data output from a KY-585 Vocoder, and two-dimensional discrete Fourier transforms with spatial frequency filters. Two male speakers generated data for the computer processes which include a speaker adaptation routine. A relation to the human physiology is maintained through an elementary model. For a 39 word vocabulary, recognition rates reached 92% for the single speaker process, and 79% for an either-of-two-speaker process. Departures from visual pattern recognition techniques are introduced and proven effective.

60. A STUDY OF THE EFFECT OF SIGNAL OVERLAP ON OPTIMUM DETECTABILITY

Robert N. Detelich, Maj, USAF — 113p — GE/EE/72-9
Advisor: Lt Hatsell — Lab Sponsor: AFCRL

An optimum sequential detector design developed by L. W. Nolte is modified for an overlapping sporadic Poisson Signal case. Receiver operating characteristics are derived by a computer simulation for a range of parameter variation - signal/noise ratio, length of interval, and generation probability - for the signal-known-exactly case. Tests of the overlapping signal-known-statistically and nonoverlapping signal-known-exactly cases are also performed. Detectability variation with parameters is plotted and analyzed for all tests. A conclusion is that for equal signal energy detectability of overlapping and nonoverlapping cases is essentially equal.

61. A STUDY OF RF SPUTTER ETCHING IN AN ARGON PLASMA USING SILICON AS A TARGET

William G. Duke, Maj, USAF — 113p — GE/EE/72-10
Advisor: Prof J. Lubelfeld — Lab Sponsor: AFAL — AD 742436

Highly reproducible etch rates were achieved by sputter etching on silicon and aluminum targets in an RF generated argon plasma. The target materials were subjected to a number of different etching conditions to evaluate the dependence of etch rate upon electrode separation, argon pressure, self-biasing voltage, and a static magnetic field. Formulas for etch rate dependence upon the self-bias voltage and magnetic field were derived from theoretical considerations and experimental observations. Plasma contamination and masking technique were critical factors. With the proper selection of etching conditions, etch rates were reproduced with an error less than 5%.

62. APPLICATION OF CV CHARACTERISTICS TO CONTROLLING MIS PROCESSING

Robert A. Fritschie, — 68p — GE/EE/72-12
Advisor: Prof J. Lubelfeld — Lab Sponsor: AFML — AD 742430

The purpose of this report is to determine the usefulness of the capacitance-voltage (CV) method as a process control tool. To accomplish this task a study of the physics of MIS structures and the theory of the CV method are given. Then it is shown how the method can be used to obtain various physical properties of the semiconductor, insulator, and semiconductor-insulator interface. Where appropriate, examples of the evaluations are given. A computer program which facilitates the determination of various properties from the CV characteristics is included in the appendix. The substrate material used is n-type silicon and the kinds of insulators investigated in this study are: Si_3N_4:SiO_2, Al_2O_3:SiO_2, and SiO_2.

63. DESIGN OF A LONGITUDINAL FLIGHT CONTROL SYSTEM FOR A STOL TRANSPORT IN THE LANDING CONFIGURATION

Edwin L. Hamilton, Capt, USAF — 107p — GE/EE/72-13
Advisor: Lt Col R. A. Hannen — Lab Sponsor: AFFDL — AD 742314

The longitudinal dynamics of a medium STOL transport are studied to determine the augmentation necessary to provide an acceptable longitudinal flight control system, and a flight control system is synthesized and evaluated. Wind tunnel data is analyzed and an operating envelope is defined. Longitudinal handling qualities of the unaugmented aircraft are compared to Air Force requirements, and design criteria are formulated. A longitudinal flight control system which utilizes parallel actuation of both elevator and direct-lift control spoilers through movement of the pilot's stick is synthesized using root locus techniques. The system is based upon control of the flight path.

64. REGULAR EXPRESSIONS AND SUBSET-SPECIFIED SEQUENTIAL MACHINES

Edward S. Hinton, Lt Col, USAF — 55p — GE/EE/72-14
Advisor: Maj T. Purnhagen — Lab Sponsor: AFIT — AD 742435

The relationship between regular expressions and subset-specified sequential machines is derived through the use of a specialized

machine, the subset-specified tape acceptor. This machine is described by two regular expressions, one of which represents the set of sequences which is an upper bound to the set accepted by the machine, and the other, the lower bound. An inverse procedure is presented which starts with two regular expressions, one which represents a set of sequences that must be accepted, and another which represents a set that may or may not be. From these, a subset-specified sequential machine is derived which can be reduced by the method of Purnhagen to a completely specified machine which accepts the required set of sequences. The regular expression for the set of sequences that may or may not be accepted is directly analogous in sequential machines to the "don't-care" minterms which are used in combinatorial functions for minimum-cost realization.

65. REDUCTION OF SULFUR DIOXIDE USING MICROWAVE DISCHARGE TECHNIQUES

John E. King, 1st Lt, USAF — 54p — GE/ME/72-1
Advisor: Maj R. Jensen — Lab Sponsor: AFIT — AD 741258

Sulfur dioxide concentrations were reduced in a microwave discharge to investigate a possible system for industrial application. An 85 watt, 2450MHz microwave power generator and resonant cavity were used to sustain the discharge in a low pressure system. Static discharge tests of varied time duration were conducted to determine the dependence of SO_2 reduction on molecular residence time. The reduction of pure SO_2 in the discharge resulted in the formation of SO_3 and S. The net reduction of SO_2 was unacceptable for industrial use; thus, leading to investigations of SO_2 mixed with selected gases. Carbon dioxide and C_2H_4 were effective in improving the net reduction of SO_2 in short term discharges (5-20 sec). Ethylene acted as an oxygen scavenger in the SO_2 reduction while CO_2 acted as an oxygen donator forming SO_3. Upon exposure to water vapor SO_3 reacts to form H_2SO_4. A flow system was established to simulate an industrial gas flow; however, realistic volumetric flow rates could not be achieved due to restraints imposed by the experimental apparatus. A pure SO_2 and a SO_2-C_2H_4 mixture was investigated. Visible quantities of sulfur products were precipitated in a cooled U-trap downstream of the discharge. Results of this experiment indicated that the reduction of SO_2 concentrations by means of a microwave discharge process has possibilities for industrial application.

66. A PHASED ARRAY WITH HEMISPHERIC SCAN FOR SATELLITE TRACKING

Thomas B. Markham, Capt, USAF — 91p — GE/EE/72-15
Advisor: Prof Taylor — Lab Sponsor: AFAL — AD 742433

The possibility of replacing large highly directive parabolic antennas for satellite tracking with a phased array is investigated. It is shown that a non-planar array with a circular horizontal cross section and an elliptical vertical cross section has a far field radiation pattern suitable for satellite tracking. The problem is formulated for solution by a high speed digital computer and an analysis of the performance of the optimal array design is presented.

67. AN ANALYSIS OF AN ELECTROMAGNETIC TRANSMISSION LINE OF ELLIPTICAL CROSS-SECTION WITH REGARD TO MAXIMUM UNIFORMITY OF FIELD IN THE ENCLOSED REGION.

Arthur L. Morse, Jr., Capt, USAF — 55p — GE/EE/72-16
Advisor: Prof Taylor — Lab Sponsor: AFWL

A study is made of the field uniformity of an elliptic cross-section electromagnetic transmission line. A solution maximizing the area over which the field is acceptably uniform is sought by direct means and found to be impractical. A computer simulation is then used to find the optimum elliptical cross-section. Comparison is made with the field uniformity of a parallel plate line and it is seen that a large improvement is possible by utilizing the elliptical geometry.

68. A STUDY OF FUNCTIONAL COMPATIBILITY OF VERSATILE CIRCUITS

James A. Muldowney, Capt, USAF — 46p — GE/EE/72-17
Advisor: Prof J. Lubelfeld — Lab Sponsor: AFIT — AD 742434

An analysis was made of the set of relationships that exist between the electronic functions and the possible specifications of an arbitrary list of functions, for the purpose of developing a method of determining the compatibility of these functions in a single versatile circuit. A set of compatibility tests was devised. One of the tests was to determine the feasibility of fabricating a physical circuit that would perform with prescribed versatility. Two examples of circuit design were discussed, as were methods of extending these design principles to other circuits. Also, some techniques of optimization for individual functions were explored. The results of this study are that, an arbitrary list of functions can be tested for compatibility, and if compatible, a circuit can be designed that will perform these functions.

69. DIGITAL LOGIC SIMULATOR

John R. Niederhauser, Capt, USAF — 144p — GE/MA/72-1
Advisor: Prof C. Richard — Lab Sponsor: AFAL

Digital Logic Simulator (DLS) is a CDC 6600 computer program which simulates synchronous and asynchronous networks of digital logic elements. It is used at the Air Force Institute of Technology to verify digital logic designs. DLS uses a state variable model which associates time delays with all elements. Thus, the effects of propagation delays on circuit behavior can be analyzed. DLS has four operation modes which allow the user to test circuits at various levels of complexity. The DLS input source data is taken directly from the circuit diagram. Each signal in the circuit must be labled with a unique name. Using the DLS language, the designer prepares a description of the circuit to be simulated. This description consists of patching statements. A patching statement lists the element type, its output signal name, and all of its input signal names. The user may also specify circuit parameters such as initial conditions and delays. Using this data, DLS compiles an internal representation of the circuit. Then DLS recursively calculates outputs for all elements in the circuit using input bit sequences provided by the user. A timing table is created which lists the resulting output bit sequences. A complete users manual is included in the thesis which describes the detailed features, capabilities, and language specifications for DLS.

70. A DIGITAL SIMULATION OF PSYCHOLOGICAL CORRELATES OF A MODEL OF THE HUMAN VISUAL SYSTEM

William O. Ragsdale — 62p — GE/EE/72-19
Advisor: Dr. M. Kabrisky — Lab Sponsor: AMRL — AD 742431

The purpose of this investigation is to establish psychological correlates for a transform model of the human visual system and to determine the model's ability to exhibit Gestalt grouping principles and visual illusions. Psychological correlates were obtained by comparing human visual performance to the computer model's performance; the correlation factors were high. Patterns containing Gestalt grouping principles and various visual illusions were presented to the filtered transform model to determine its ability to exhibit them in reconstructed images after low-pass filtering. Reconstructed images clearly show these characteristics.

71. A FACILITY FOR HIGH RESOLUTION RAPIDLY PROGRAMMABLE INTEGRATED CIRCUIT MASK PRODUCTION

Thomas J. Ramrath, Lt, USAF — 83p — GE/EE/72-20
Advisor: Prof J. Lubelfeld — Lab Sponsor: AFML

The design and construction of this facility centered around a computer controlled, final size, integrated circuit Mask-Maker. The machine was housed in a room set aside by AFIT for microphotographic techniques. The room was modified to suit the stringent requirements of microphotography with consideration given to expansion of the facility into the area of photo-resist techniques. Solutions and equipment were designed for developing the resulting microphotographs and an operator's manual written as an appendix to aid the student in the use of the facility. The manual and the facility were tested by a person unfamiliar with microphotographic techniques but with a technical background. It was found that the manual gave adequate instruction for the use of all the equipment and processes.

72. DEVELOPMENT OF INPUT/OUTPUT INTERFACE FOR THE D-17B COMPUTER

Robert M. Schaff, Lt Col, USAF — 122p — GE/EE/72-21
Advisor: Dr. G. Lamont — Lab Sponsor: AFLC — AD 742438

A synchronous serial-binary D-17B Computer, removed for a surplus Minuteman I missile, was added to the facilities of the Digital Engineering Laboratory at the Air Force Institute of Technology, WPAFB, Ohio. This report briefly describes the computer then presents information on the design and construction of interface circuits and controls for operation of a teletypewriter, a photoelectric paper tape reader and a high speed paper tape punch with the computer. Integrated circuit logic elements and wire wrapping techniques are used expensively. The resulting system enables digital engineering students to program the computer and to use it for laboratory experiments and research projects.

73. PAFIC - A SMALL GENERAL PURPOSE DIGITAL COMPUTER

Muti H. Siddiqi — 144p — GE/EE/72-22
Advisor: Maj T. Purnhagen — Lab Sponsor: AFLC

A small general purpose digital computer is described which can be used as an effective teaching aid. The computer design is divided into three phases; in the system design phase the specifications are translated in terms of word format, computer organization and structure, and also a set of instruction codes is selected. In the symbolic design phase, symbolic statements and a state diagram are developed to describe the sequential operation of the computer. Machine simulation is helpful in detecting logic design faults. In the last phase, details of various sub-units of the control, memory and arithmetic units are developed in terms of Boolean equations. These equations are implemented using transistor-transistor logic J-K flip-flops and NAND gates. The program is loaded manually into the memory by operating console switches. It can be run either at a slow speed to study inter-register transfers or at a fast speed to solve a problem quickly. Programs can be written using fourteen instructions. Illustrative programs are included to show computational capabilities of the computer.

74. CLASSIFICATION OF OVERLAPPING WAVEFORMS WITH PATTERN RECOGNITION TECHNIQUES

Dennis E. Small, Capt, USAF — 83p — GE/EE/72-23
Advisor: Lt Hatsell — Lab Sponsor: AFCRL — AD 741734

An investigation of the utility of pattern recognition techniques in the classification of overlapping waveforms is made using Sporadic-Poisson signals as a model. The signals consist of repetitions of three-bit binary components which occur and also overlap in a random manner. The sporadic occurrence rate and overlap features of the signal model approximate to some extent the nature of overlapping radar returns from closely spaced targets. Elements of pattern recognition models applied include the Fast Fourier Transform, filtering in the discrete frequency domain, and the Euclidean distance metric. Classification tests are made on four types of Sporadic-Poisson signals using various filtering combinations (including variance filters) and with a nearest prototype classification rule.

75. GROWTH OF EPITAXIAL GALLIUM ARSENIDE BY THE VAPOR PHASE PROCESS

James E. Stangel, Capt, USAF — 110p — GE/EE/72-24
Advisor: Capt T. Owen — Lab Sponsor: AFAL — AD 742428

The vapor phase process was used to grow n-type epitaxial gallium arsenide. The system was an open flow type, using the reagents gallium, arsenic trichloride, and hydrogen. The importance of initiating growth after saturating the gallium source with arsenic was demonstrated. The growth rate was shown to be highly dependent on both substrate temperature and total flow rate. It was shown that a higher arsenic trichloride concentration resulted in a lower net donor concentration within the epitaxial layer.

76. A TWO-DIMENSIONAL WALSH TRANSFORM COMPUTER

Richard V. Swartwood, Capt, USAF | 68p | GE/EE/72-25
Advisor: Dr. M. Kabrisky | Lab Sponsor: AMRL | AD 742432

A recursive algorithm for the discrete Walsh transform is presented which leads to an efficient hardware implementation. The flow diagram of the algorithm constitutes a block diagram for a transform computer requiring only N $\log_2$ N computations where N is the number of input elements. A 16 x 16 two-dimensional Walsh transform computer based upon the algorithm was constructed. The recursive structure of the algorithm allows a hybrid implementation requiring only 256 operational amplifiers, rather than 2048, where each amplifier is used eight times through a feedback loop. The savings in the number of amplifiers comes at a cost of sample-and-hold circuits at the input and output of each channel, the necessary feedback control logic, and the time required for feedback. This results in a considerable cost savings and reduction in the size and complexity of the transform computer. Relatively inexpensive sample-and-hold circuits are used with the result that 700 microseconds are required to compute a transform. This is over 100 times faster than software for the PDP-12 computer (with which the transform computer will be interfaced), but more important, the PDP-12 will be freed for other operations, such as processing previously stored data.

77. A DIGITAL LOGIC DESIGN CONSOLE

Clyde C. Turquette, Capt, USAF | 100p | GE/EE/72-26
Advisor: Maj T. Purnhagen | Lab Sponsor: AFIT | AD 742427

A need exists in the Electrical Engineering Department at AFIT for a digital laboratory in which practical applications of courses taught in switching theory and digital systems can be made. Part of this need is filled by the digital logic design console described in this thesis. The console consists of a collection of TTL integrated circuit logic elements mounted on interchangeable panels. The logic elements are connected through the use of patch cords. There is sufficient logic to construct complex combinational circuits and even a small computer complete with a semiconductor memory. The result is a reliable and flexible system that can perform many functions in the laboratory.

78. FEASIBILITY STUDY OF WHOLE AIRCRAFT AS AN APERTURE ANTENNA

Samuel R. Weaver, Maj, USAF | 34p | GE/EE/72-27
Advisor: Prof Taylor | Lab Sponsor: AFAL | AD 742439

A set of assumed conditions that must be met to realize a radar antenna that conforms to a flexible irregular shape such as an aircraft surface are given. The theory and properties of adaptive arrays are reviewed along with the properties of aperiodic arrays. The results of some experimentation is cited to support the theory. An argument is then presented that by use of adaptive array techniques and widely spaced (several wavelengths) array elements it is feasible to realize an airborne radar antenna that will conform to any desired shape. It is argued that it is feasible to determine target position by a combination of pattern computation and interferometer techniques having knowledge of the location of a relatively small number of the antenna elements.

79. SEISMIC DISCRIMINATION BY HARMONIC ANALYSIS TECHNIQUES

William R. Youngblood, 1st Lt, USAF — 85p — GE/EE/72-29
Advisor: Capt C. Hall — Lab Sponsor: TAC — AD 743317

A large set of short period earthquake and underground nuclear explosion teleseismic signals (recorded at LASA) were analyzed using bands of the Discrete Fourier Transform coefficients and a pattern recognition system. The earthquakes, from several regions, ranged in magnitude from 4.1 to 6.1, and included shallow and deep events. The explosions ranged in magnitude from 4.7 to 6.3, and included US, Soviet, and French shots. Best results were 88.9% of the earthquakes and 100% of the explosions correctly identified. Furthermore, when deep and unknown depth earthquakes were excluded, only one earthquake was misidentified.

80. LABORATORY CONVERSION AND STATE DESCRIPTION OF THE D-17B COMPUTER

Douglas J. Allen, Capt, USAF — 121p — GE/EE/72S-2
Advisor: Dr. G. Lamont — Lab Sponsor: AFLC — AD 746008

The D-17B computer is a digital minicomputer that is used in the NSQ-10 Minuteman I missile guidance system. This system has been made available for reutilization by qualifying agencies. Documentation concerning the procedures for converting the computer for general purpose use is being generated by the Minuteman Computer Users' Group. This report is addressed toward part of that effort. Before the conversion process is begun the computer may be tested to determine useability. An inexpensive forced-air cooling system will allow operation at ambient air temperatures up to 85°F. Fragmentary descriptions of the D-17B previously available are supplemented in this report by a description using the states of control flip-flops. This state description is useful as a study plan and a maintenance guide. Suggestions of educational applications and a data input bus are included. This thesis can provide the information necessary to convert the D-17B to a laboratory computer and it contains data for those interested in similar conversion projects.

81. ANALYSIS OF A 10.6-MICRON PRINTED-CIRCUIT ANTENNA ARRAY

Henry W. Myers, Maj, USAF — 47p — GE/EE/72S-1
Advisor: Prof Taylor — Lab Sponsor: AFAL — AD 742440

A printed-circuit antenna array for a wavelength of 10.6 microns is shown to be feasible, using analysis by the method of moments. The method of moments is a technique whereby classical electromagnetic problems may be solved numerically rather than analytically using high-speed digital computers. Potentials are used as the basis for the electromagnetic boundary conditions, resulting in a series of linear, partial differential equations. An example of a thin dipole is analyzed before proceeding to the more complicated infrared dipole. Due to present printed-circuit technology, the infrared dipole must be a two-dimensional dipole, resulting in both axial and lateral components of current. Analysis shows that the lateral current, although fairly large, may be dropped without affecting the dipole radiation pattern. Mutual coupling between dipoles is used to determine the radiation pattern from the system; the result is a pencil beam normal to the plane of the antenna array.

82. THEORETICAL CALCULATION OF X RADIATION FROM NON-EQUILIBRIUM ALUMINUM PLASMAS

Robert W. Boyd, 1st Lt, USAF — 78p — GEP/PH/72-1
Advisor: Prof D. Shankland — Lab Sponsor: AFWL — AD 744813

TORCH, a computer code which calculates the spectrum arising from the radiation of a metallic plasma, is described. The population of each ionic species is determined from a time-dependent corona model which includes three-body recombination. Both time-resolved and time-integrated spectra are obtained, showing the contributions from bremsstrahlung, recombination radiation, and line radiation. Ion and electron temperatures are allowed to differ, with radiative losses causing continuous electron cooling. Energy may be added to the electrons and/or ions at arbitrary rates, for arbitrary times, and TORCH will compute the temperatures based on the rates of radiation, ionization, and electron-ion energy exchange. Calculations are included for aluminum plasmas with electron densities of 10^{18} to $10^{21}/cm^3$ and electron temperatures of 10 eV to several KeV. Also included are calculations of radiation from a deuterium plasma with 5% aluminum impurities.

83. AN INVESTIGATION OF THE DETECTION OF CHARGED METAL PARTICLES IN A JET ENGINE EXHAUST BY A CYLINDRICAL ELECTROSTATIC PROBE

Ray W. Burgess, Jr., Capt, USAF — 75p — GEP/PH/72-2
Advisor: Prof D. Shankland — Lab Sponsor: AFFDL — AD 745540

Charged particle detection by an electrostatic probe in a jet engine is studied from both a theoretical and an experimental approach. The charging mechanisms for a metal particle in a jet engine exhaust are presented and discussed. A theory for the waveshape expected for a charged metal particle moving perpendicular to a cylindrical electrostatic probe is developed. The theory is developed using an electronic circuit equivalent to the physical mechanisms in the jet engine. A laboratory burner is described which simulates the exhaust ion number density and lower thrust values of a jet engine. Experimental data are presented for the burner and for a scaled up system which uses a 0.44 cm diameter particle, a 7.6 cm diameter probe, and a 30 cm/sec velocity. The theory predicts a bipolar current spike for a particle missing the probe and a monopolar spike for a particle that hits the probe. The scaled up system produces current spikes predicted by the theory, but the burner experiment does not. The reason for the unpredicted spikes is the lack of particle charging due to the absence of spray charging in the burner. This shows that spray charging is a very significant charging mechanism in jet engines. The burner experiment also shows that there is a linear relationship between the logarithm of the exhaust number density and the fuel/air ratio for the burner.

84. TEM_{oo} MODE ANALYSIS OF COMPLEX LASER CAVITIES

Glenn R. Doughty, Capt, USAF — 86p — GEP/PH/72-3
Advisor: Maj K. Jungling — Lab Sponsor: AFAL — AD 746215

A method of analyzing the dominant TEM_{oo} mode of complex laser cavities is presented. The basic theory required for this analysis is summarized and extended to apply to cavities containing relatively short elements. This extension, accomplished by including third order expansion terms to describe short cavity elements, is specialized to cavities containing one plane mirror, one spherical mirror, an intra-cavity-aperture, and a laser rod exhibiting a non-uniform gain distribution. The integral equation obtained by applying this theory is solved by the method of successive approximations. The computer program used to solve the integral equation for the TEM_{oo} mode pattern, diffraction loss, and other cavity parameters is presented. The computational procedure employed and the input data required by the program are discussed in detail. The results of computer runs for laser cavities in which intra-cavity aperturing and non-uniform gain effects are small are in excellent agreement with predictions made using Gaussian Optics. This agreement, which demonstrates that the program is working properly, is illustrated by computer plots of the predicted TEM_{oo} mode distributions. It is recommended that the program be improved and extended to cover more complex laser cavities.

85. ATMOSPHERIC CONTRAST TRANSMISSION: APPLICATION TO THE VISUAL DETECTION AND ELECTRO-OPTICAL LOCK-ON PROBLEM

Edward A. Duff, Capt, USAF — 175p — GEP/PH/72-4
Advisor: Prof D. Shankland — Lab Sponsor: AFSA — AD 743560

The contrast and size of the target limit detection or lock-on range. Models for the prediction of detection range are evaluated in this report. The contrast available at the eye or the electro-optical sensor is assumed to be the limiting factor. The atmosphere provides a transmission factor for the target-background contrast. A model for the prediction of contrast transmission proposed by Duntley in 1948 is examined. Duntley's work provides an analytic solution based on an equation which relates visibility to air-transmittance along an inclined path, and a table of sky-ground ratios. An improved relation for visibility is developed by the author. More realistic sky-ground ratios are obtained from calculated data and from flight tests. The RRA Monte Carlo model and the AWS model, which predict contrast transmission, are compared for accuracy. The AWS model is also compared to recent flight data. The AWS model is shown to predict generally higher results than the RRA data, due to the approximations used. The AWS model does provide a useful, fast tool for prediction of contrast transmission. A more recent concept developed by Duntley, the directional path reflectance R*, is used to describe the atmospheric effects. R* provides a useful single parameter for evaluating a situation to determine approach angles where the effect of haze is a minimum. The directional background reflectance $_bR_0$ must be used with R* to predict contrast transmission. Graphs illustrating the application are presented.

86. A STUDY OF LAPLACE'S AND POISSON'S EQUATIONS IN THREE DIMENSIONS USING NUMERICAL GREEN'S FUNCTIONS

Philip F. Fry, Jr., Capt, USAF — 60p — GEP/PH/72-5
Advisor: Prof B. Kaplan — Lab Sponsor: AFIT — AD 745429

A study of LaPlace's and Poisson's equations, applied to the rectangular parallelepiped, was conducted using the CDC 6600 computer. The speed and accuracy of the numerical Green's function solutions were probed and compared with standard analytical and difference equation approaches. The Green's functions were obtained from both analytic and difference expressions. Successive overrelaxation (SOR) was used with iterative techniques. Some optimum relaxation factors for LaPlace's and Poisson's equations in rectangular parallelepiped geometry are listed for dimensions two by two by two through 20 by 20 by 20. The results show acceptable accuracy for the Green's function solutions for both equations, with a percent RMS error decreasing to near 1.5% for the largest lattice studied (12^3 lattice points). As the number of lattice points was increased, the speed advantage of the Green's function approach decreased. For LaPlace's equation with boundary conditions on one surface of the 12^3 lattice, the Green's function solution was twice as fast as the SOR approach. For Poisson's equation with a 12^3 lattice, the Green's function was only 1/6 of the speed of the SOR method.

87. RADIO BURSTS AND GEOMAGNETIC STORMS

Paul W. Hiday, Capt, USAF — 29p — GEP/PH/72-6
Advisor: Prof H. Wilson — Lab Sponsor: AFIT

This study investigated 56 spectral radio bursts for their relationship to geomagnetic storms. Type II, type IV, and the type II - type IV combined bursts were the only types of radio bursts investigated. For the combined type II - Type IV burst there was an 88% match. The transport time for the plasma shell associated with the solar burst was found to agree with the theoretical data.

88. PHOTOEMISSIVE INVESTIGATIONS OF THE BAND STRUCTURE OF HEXAGONAL SINGLE-CRYSTAL ZnS

Eugene R. E. Johnston, Lt, USAF — 69p — GEP/PH/72-7
Advisor: Prof R. Hengehold — Lab Sponsor: ARL

Photoemissive measurements were made on single-crystal hexagonal ZnS using 21.2 eV (584A) and 16.8 eV (740A) radiation. Samples were cleaned and measured in an oil free vacuum system at pressures in the 1×10^{-6} - 1×10^{-7} Torr range. The sample resistance, originally 1×10^{11} ohms, was reduced to 1×10^{6} ohms by baking in a controlled zinc atmosphere for approximately ten days. Data obtained was analyzed on the basis of non-direct transitions. Four pieces of structure in the energy distribution curves obtained are observed. High density of states associated with the valence band are located at 2.0 eV, 5.8 eV, and 8.2 eV below the valence band maximum. The structure located at 8.2 eV below the valence band maximum is identified as being due to the Zn 3d level. One density of states region is identified in the conduction band and is located at 9.8 eV above the valence band maximum. Considerable shifting of peaks on the EDC was observed. It is believed that this shifting was caused by a large space charge being built up on the surface of the sample.

89. ELECTRON ENERGY LOSS SPECTRA OF HgS, HgSe, and HgTe

Thomas T. Katonak, Capt, USAF — 50p — GEP/PH/72-8
Advisor: Prof R. Hengehold — Lab Sponsor: ARL

Electron loss measurements have been made on crystals of HgSe, HgTe and hexagonal HgS over the energy range of 0 to 50 eV by reflection techniques. The resulting energy loss spectra have been compared to optical reflectivity and ESCA measurements, and recent band calculations. Interband transitions were recorded between 2.5 and 9 eV, surface plasmons near 9 eV, spin-orbit split d-band transitions at 10 to 14 eV, and volume plasmons at 15 to 20 eV for the three compounds. In addition, a transition from the Te 4d core level in HgTe was observed.

90. A VACUUM GRATING MONOCHROMATOR FOR THE FAR INFRARED

John N. Kirkham, Capt, USAF — 58p — GEP/PH/72-9
Advisor: Prof R. Hengehold — Lab Sponsor: ARL

A vacuum grating far infrared monochromator was constructed. It used 7 x 9 inch gratings in a Czerny-Turner system with a focal length of 60 inches. The system was on an optical bed which could be rolled in and out of a large vacuum tank. The gratings and reststrahlen plate filters used were kinematically mounted so that they could be easily exchanged without changing alignment. The source used was a Globar; the detector, a golay cell. The system was tested and made operational in the 20 to 70 micron range. Spectral energy profiles of the gratings used in this range were plotted and the atmospheric absorption was shown. Resolution of 1.45 cm^{-1} was shown at 358 cm^{-1}, and the system was used to detect the LO + TO mode multiphonon absorption band in a CdSe platelet.

91. SIDELIGHT SPECTROSCOPY OF A CARBON DIOXIDE LASER AMPLIFIER

David A. LaBorde, Maj, USAF — 78p — GEP/PH/72-10
Advisor: Prof D. Shankland — Lab Sponsor: ARL — AD 743567

A method for determining the vibrational energy distribution of nitrogen molecules in the electronic ground state in a Carbon Dioxide-Nitrogen-Helium laser amplifier was evaluated. This method relates the relative population of the $C^3\pi_u$ electronic state to the relative population of the ground state of nitrogen. The relative population of the $C^3\pi_u$ electronic state was determined by measuring the relative intensities of the electron-vibrational bands of the second positive system of nitrogen. These measurements were conducted as the laser amplifier parameters, discharge current, total pressure, carbon dioxide concentration, and input power, were varied. It was found that the relative population of the $C^3\pi_u$ state was insensitive to changes in the laser amplifier parameters over a range significant to its operation. It was concluded that a relatively low number of nitrogen molecules exist in the first vibrational level of the electronic ground state under discharge conditions. Measurements of spontaneous emission from the upper laser level of carbon dioxide were conducted and the results support this conclusion.

92. X-RAY INDUCED ELECTRON EMISSION STUDIES OF SEVERAL III-V COMPOUNDS

Teddy L. Lane, lst Lt, USAF 83p GEP/PH/72-11
Advisor: Dr. R. Hengehold Lab Sponsor: ARL

X-ray induced electron emission measurements were used to determine the energy levels of core electrons in GaAs, GaP, InAs, and InSb. Ion bombardment was used to clean the samples prior to measurement and to deposit a thin film of gold on their surfaces for the purpose of energy calibration. The investigated energy range extends from 16 eV to 1400 eV below the Fermi level. Chemical shifts were determined by comparing the results of these measurements with experimental values for the pure elements. The measured core levels for GaAs and InSb were compared with self-consistent relativistic orthogonalized plane wave calculations. For GaAs, theoretical calculations were available using Slater's exchange and Kohn-Sham's exchange. Slater's exchange approximation yielded results which were in much better agreement with the measured values. Spin-orbit splitting values were determined for several levels and the results compared, with good agreement, to theoretical calculations and other experimental values. The In 4p, As 3d, and Sb 4p splitting values were determined experimentally for the first time. The values measured for the upper p and d levels were compared with transition energies determined by optical absorption, optical reflection, and electron energy loss in order to determine regions of high density of vacant states in the conduction band. These energy regions were compared with theoretical band structure calculations.

93. LOCK-ON RANGES OF LASER-GUIDED SYSTEMS

James V. Mardis, Capt, USAF 95p GEP/PH/72-12
Advisor: Dr. L. S. Pedrotti Lab Sponsor: AFSA AD 744814

This thesis is an evaluation of the factors that determine the maximum acquisition and tracking (lock-on) range of laser-guided systems in the military close-air-support mission. The problem is divided into a study of the designed system parameters which are characterized by a clear-air lock-on range, and a study of the effect of the intervening atmosphere. Three model atmospheres are considered: a homogeneous, an exponential, and a three-layer stratified atmospheric aerosol vertical structure. The vertical aerosol number density distribution of a real atmosphere can be bracketed between a homogeneous and an exponential atmospheric model. Conversion charts from clear-air lock-on range to actual lock-on range for the three model atmospheres are plotted. It was found that beamspreading by aerosols can be large for moderate attenuation coefficients. Reflective cross sections of a jeep model were found to have a standard deviation of ±20% of the mean for two olive drab paints. Attenuation coefficients at 1.065 microns are determined for atmospheric gases and rain. A method is presented for determining aerosol attenuation at 1.065 microns from the visibilities measured through red and blue filters; comparison of this method with the computer analysis by others was successful but experimental tests were inconclusive due to equipment and weather problems.

94. LINEARIZED THEORIES OF IONIZATION WAVES

Robert S. McCulloch, Capt, USAF — 50p — GEP/PH/72-13
Advisor: Dr. G. Soper — Lab Sponsor: ARL — AD 744815

A model for ionization waves in a D.C. gas discharge is developed in a straightforward manner based on the linearized first three moment equations for positive ions and electrons and Poisson's equation. Slab symmetry is imposed. The predictions obtained by applying this model to discharge conditions for which ionization waves have been observed are in good qualitative agreement with both the results of experiment and the predictions of other theories. The effects of including small perturbations in ion temperature and electron neutral momentum transfer collision frequency and energy transfer collision frequency are also discussed.

95. AN INVESTIGATION INTO THE CAUSES FOR THE SHORT LIFETIMES OF GEIGER-MULLER TUBES USED IN AIRCRAFT OIL GAUGING SYSTEMS

Dale E. Morin, Capt, USAF — 53p — GEP/PH/72-14
Advisor: Dr. G. John — Lab Sponsor: AFFDL — AD 746267

The causes of failure of the G-M detectors used in the nucleonic oil gauging system of USAF aircraft are presented. Experimental tests performed on several tubes, in simulated aircraft environments, proved that the detectors fail because of a depletion of the halogen quench gas. A variety of surface analyses established that the halogen gas reacted with both the cathode and anode surfaces. On the cathode the halogen (bromine) attack was always co-located with lead deposits and the only known source of lead inside the counter is from the glass solder used as the tube sealant. The anode showed two types of bromine attack: A fairly uniform attack of the entire surface and a highly localized attack on abraded regions. These abrasions were evident on every detector that failed in the simulated aircraft environment. Recommendations are made to increase the G-M tube longevity. Implementing these recommendations require only minor modifications to the basic system.

96. NEW Nd:YAG $^4F_{3/2} \rightarrow {}^4I_{9/2}$ LASER TRANSITIONS

Patrick J. Pomphrey, Jr., Capt, USAF — 67p — GEP/PH/72-15
Advisor: Maj K. Jungling — Lab Sponsor: SAMSO — AD 746218

The objective of this investigation was to study $^4F_{3/2} \rightarrow {}^4I_{9/2}$ laser transitions in a pulsed Nd:YAG laser, end-pumped with the focused output of a high power, pulsed xenon-ion laser. The major efforts described in this thesis included optimization of pump power, selection of dispersive elements for wavelength selection, prevention of laser damage to optical elements, identification and verification of new Nd:YAG laser wavelengths, measurement of 0.946 μm laser threshold as a function of temperature, and preliminary calculations of stimulated emission cross-sections. Room temperature oscillations at 1.064, 0.946, 0.939, 0.900, 0.891, and 0.885 μm were obtained, the latter four being new Nd:YAG laser wavelengths. Dominance of the 0.946 μm line between 300 and 110°K and the 1.061 μm line between 110 and 84°K prevented further analytical studies of the 0.885, 0.891, and 0.900 μm lines at low temperatures, although the latter two oscillated at 213°K. Threshold data for the new laser lines were inconclusive, however, as the necessary single-line oscillation was not obtained. Preliminary

results for the 1.064 and 0.946 μm lines indicate stimulated emission cross-sections of ∿3 x 10 ^{19} and ∿6 x 10 (-20) cm^2, respectively. Removal of dominance by use of a diffraction grating instead of the Littrow prism for the output reflector is required for further studies of the new Nd:YAG laser transitions.

97. LASER INDUCED DAMAGE IN INHOMOGENEOUS OPTICAL COATINGS

Joe M. Putman, Capt, USAF — 84p — GEP/PH/72-16
Advisor: Dr. Guenther — Lab Sponsor: AFWL — AD 749852

The structural effects of various optical coatings on their single shot laser induced damage threshold is discussed. Films were subjected to irradiation by a pulsed neodymium glass laser. In an attempt to isolate the influence of film stress on damage threshold, various stress films were constructed by mixing two component materials of similar damage thresholds but opposite stress characteristics. Results showed that stress-relieved films had higher damage thresholds. Additional vapor phase mixture films were prepared from component materials of widely different damage thresholds, changing the mixing ratio for each film. Damage results showed that thresholds for mixtures lie between the thresholds for each component, being somewhat dependent on the amount of each component present in the film. Periodic inhomogeneous and "equivalent" discrete single and multiple layers were constructed and damage results compared. Both types of preparation showed similar damage results. The damage thresholds tended to decrease as the number of layers or cycles was increased. Discrete films showed a damage dependence on the angle of incidence of deposition. Results confirm that damage thresholds are very much material and residual stress dependent.

98. DESIGN AND ANALYSIS OF A SYSTEM FOR THE STUDY OF ATMOSPHERIC TURBULENCE EFFECTS ON LASER BEAM PROPAGATION

Dennis H. Quine, Capt, USAF — 52p — GEP/PH/72-16
Advisor: Maj K. Jungling — Lab Sponsor: SAMSO

A system was designed and assembled to gather data on laser beam wander and scintillation. The system was set up between the laser communications lab at Aerospace Corporation (transmitter) and a receiver on Palos Verdes mountain, in Los Angeles, Ca. Path length was 15.5 kilometers, and two lasers were used: a He-Ne laser (1.5 milliwatt, 6328A), and a He-Cd laser (15 milliwatt, 4416A). Analysis of data initially gathered indicated that beam attenuation may vary by a factor of 10 without hampering data gathering, that beam wander rates were comparable to those reported by other researchers (between one-fifth Hertz and five Hertz), that observed scintillation scale sizes were close to those expected for the path length, and that the power spectrum of scintillation goes nearly to zero beyond 500 Hertz. Several refinements are needed before the system can provide precise data on the wavelength dependence of beam wander and scintillation.

99. COMPUTER ANALYSIS OF WINDSHIELD MULTIPLE IMAGING

Ralph H. Reed, Capt, USAF — 60p — GEP/PH/72-18
Advisor: Dr. L. S. Pedrotti — Lab Sponsor: ASD — AD 744044

A study was conducted to develop a computer technique to analyze aircraft windshields for multiple imaging. Two types of multiple imaging were considered: internal reflection, or flare, and secondary reflection. Emphasis was placed on secondary reflection multiple imaging. A CDC 6600 computer and FORTRAN were used throughout the study. A program was developed to evaluate multiple imaging in any windshield configuration reducible to a set of defining mathematical equations. Output is in the form of a matrix based on a spherical mapping. The matrix represents the pilot's effective view. The number of images the pilot will see is plotted for any given position of an object. If the conditions for internal reflection are present, a message will be printed. The program can then be altered to print a matrix map of the areas of concern. The program is based on a set of general subroutines which allow the performance of related computations, such as pilot field of view or reflection/refraction analysis. Since the visual properties of the windshield may be dependent on pilot position as well as windshield configuration, means are provided to easily change the pilot position. A sample analysis of the effect of pilot position on multiple imaging is given.

100. TESTING A POINT-DIPOLE ELECTRO-OPTIC MODEL BY AN APPLICATION TO LEAD TITANATE

August S. Sanchez, Capt, USAF — 62p — GEP/PH/72-19
Advisor: Lt Col J. S. DeWitt — Lab Sponsor: AFWL — AD 753467

A molecular point-dipole model that has been used successfully to calculate ferroelectric and electro-optic properties of the perovskite barium titanate ($BaTiO_3$) is further tested here by an application to lead titanate ($PbTiO_3$). The model calculates lorentz factors by the method of Rama Rau and the crystal's internal electric fields by the Ewald method of lattice sums. The model further treats the polarizabilities of ions as field-dependent and simulates covalency in bonds by replacing the full ionic charge by an "effective" charge. The Kerr and Pockel electro-optic constants are determined by the anisotropy induced in the refractive index by an external electric field. The calculations done showed that the model could match the experimental refractive index and dielectric constant and calculate satisfactory electro-optic constants in the cubic (paraelectric) phase, but was unable to calculate correctly the natural birefringence or dielectric anisotropy of the tetragonal (ferroelectric) phase. The model's failure in the tetragonal phase was investigated by determining the contribution to the natural birefringence by each of the different mechanisms in the model. It was found that at room temperature the contribution to the natural birefringence by the crystal lattice tetragonality or the ion displacements alone, through the lorentz factors, was at least an order of magnitude larger than the experimentally measured firefringence. The conclusion drawn is that the large c/a axis ratio and highly unsymmetrical positions of the ions in $PbTiO_3$ incorrectly dominate the model's behavior in its present form. Recommendations are to consider an explicit dependence of the polarizabilities on both the electric fields and band covalencies.

101. HIGH RESOLUTION LOW TEMPERATURE SPECTRA OF Er^{3+} in $YAlO_3$

Abraham A. Santiago, Jr., Capt, USAF — 109p — GEP/PH/72-20
Advisor: Lt Col J. S. DeWitt — Lab Sponsor: AFML — AD 743568

The absorption and emission spectra of erbium doped yttrium orthoaluminate ($YAlO_3:Er^{3+}$) have been recorded at 77°K and 4.2°K. A reduction of the data to tables of wavelengths and line strengths has been accomplished for experiments performed at 4.2°K. Tables of observed line wavelengths are included in this report. All spectra were recorded photographically. The wavelength ranges covered were 2175Å - 9500Å in absorption and 4500Å - 9500Å in fluorescence. A table of energy levels for Er^{3+} in the $YAlO_3$ host lattice is offered. A "free ion" Hamiltonian parameter fit was performed (by computer) and the results are also listed. The values obtained for the Hamiltonian parameters (based on minimization of the mean square deviation between calculated and experimental energies) were: $E^1 = 6786.2936$, $E^2 = 32.4153$, $E^3 = 643.2666$, $\zeta = 2380.6712$, $\alpha = 21.7210$, $\beta = -683.4287$, $\gamma = 389.0308$. A brief outline of the theory of complex spectra is also included.

102. DEVELOPMENT OF A SYSTEM FOR MEASURING BLOOD FLOW PARAMETERS BY THE USE OF SCINTILLATION DETECTION

Thomas R. Scott, Capt, USAF — 42p — GEP/PH/72-21
Advisor: Dr. G. Hagee — Lab Sponsor: AMRL

The Environmental Medicine Division of the Aerospace Medical Research Laboratory at WPAFB, Ohio, is currently using a centrifuge to study the effect of acceleration stress on the human body. One important parameter which would be useful to monitor is blood flow changes through various organs in the body. This system was designed and assembled as a preliminary step in the development of a system for measuring blood flow changes in humans undergoing acceleration stress in the centrifuge. A collimated scintillation detector was assembled and used to monitor gamma rays emitted from $99m_{Tc}$. The $99m_{Tc}$, in the form of sodium pertechnetate, was injected intravenously into anesthetized dogs in the laboratory and monitored as it passed through the heart, neck, and cerebral regions. The count-rate versus time curves obtained from these preliminary experiments agree qualitatively with results obtained by other blood flow investigators.

103. EXPERIMENTAL STUDY OF INSTABILITIES IN THE ELMAX

Victor R. Trouy, Capt, USAF — 49p — GEP/PH/72-22
Advisor: Dr. G. Soper — Lab Sponsor: ARL — AD 744818

An experimental search for instabilities in an ELMAX plasma device was made. Plasma generated oscillations of potential and density, with amplitudes several orders of magnitude above background noise, were observed over a wide range of plasma parameters. Measurements of plasma parameters were made with Langmuir probe diagnostic techniques. Frequencies from 3 kHz to 8 kHz were observed with phase velocity in the direction of the electron diagmagnetic drift. Ion temperature was not measured and attempted measurements of space potential were not satisfactory. By comparing the observed characteristics of the oscillations with previously identified instabilities, the instabilities responsible for the plasma generated oscillations were tentatively identified as collisional drift waves.

104. SPIN-FLIP RAMAN SCATTERING IN CADMIUM SULFIDE

Thomas W. Walker, Capt, USAF — 74p — GEP/PH/72-23
Advisor: Maj K. Jungling — Lab Sponsor: ARL — AD 746219

The 4880A line of an Argon laser was used to study the spin-flip Raman scattering in CdS at liquid helium temperature. The detection system utilized a Bausch & Lomb two meter spectrometer. The first high resolution photograph of Stokes spin-flip scattering in CdS was observed. The results with CdS indicate the feasibility of using this high resolution system in experiments with small g-factor materials such as GaAs, CdTe, and CdSe. The g-factor calculations for CdS give 1.54 at 83 KG, 1.62 at 91 KG and 1.74 at 96 KG. These results, in contrast with previous experimental data, give a smaller g-factor that varies with magnetic field. A possible explanation is that the spin-flip transition occured in a donor level rather than the conduction band. The Stokes line was found to have a very narrow linewidth .33A, and its intensity was several orders of magnitude higher than the LO and TO phonons. The scattering intensity increased with increasing magnetic field and the scattering was more intense at the edges of the crystal than at the center.

105. AN INVESTIGATION OF METHODS OF STUDYING $NdCo_5$ WITH MOSSBAUER

Charles E. Whited, Capt, USAF — 115p — GEP/PH/72-24
Advisor: Dr. G. John — Lab Sponsor: AFML

Mössbauer spectroscopy offers a method for the study of the effects of surface imperfections on the properties of $NdCo_5$. A proportional counter was designed, constructed, and tested for the detection of internal conversion electrons. Mössbauer spectra due to conversion electrons were detected with an iron-film absorber; a counting gas of 94% helium-6% methane was used to reduce interaction with low-energy gamma rays. Attempts to detect conversion electrons from a $NdCo_5$ absorber were unsuccessful. Mössbauer absorption spectra of annealed and unannealed $NdCo_5$ with Fe^{57} substituted into crystal lattice sites were obtained with a conventional Mössbauer spectrometer; spectra were obtained at approximately +25 degrees centigrade and -28 degrees centigrade. The absorbers contained randomly-orineted particles approximately 44 microns in diameter; three absorbers were used: one of annealed $NdCo_5$, one of unannealed $NdCo_5$ from the same melt, and one of unannealed $NdCo_5$ from another melt. Digital computer programs were developed to locate the absorption peaks within the spectra and to determine the spectral patterns of the peaks.

106. TEMPORAL PATTERN ANALYSIS USING MULTIDIMENSIONAL DISCRETE FOURIER TRANSFORMS

Gary H. Barber, 1st Lt, USAF — 129p — GGC/EE/72-1
Advisor: Dr. M. Kabrisky — Lab Sponsor: AMRL — AD 745995

The purpose of this investigation is to extend an existing two-dimensional Fourier transform model of the human visual system to include a temporal dimension. The first analysis considered used three dimensions, two representing space and the third representing time; it was found that by use of a temporal low-pass filter, periodic patterns could be separated from aperiodic. A subsequent analysis used only two dimensions, one representing a spatial dimension and the other time. By intermittent intensity variation upon the temporal pattern, a predicted psycho-perceptual effect was found in the model which was isomorphic to certain human perception phenomena. Further agreement with psychophysical data was found in the spatio-temporal relationship.

107. A FORTRAN MICROPROGRAM TRANSLATOR

Randall D. Godfrey, 1st Lt, USAF — 90p — GGC/EE/72-2
Advisor: Dr. G. Lamont — Lab Sponsor: AFAL

A FORTRAN program was written to translate an input card file, containing TRANSLANG statements, to microinstructions and nanoinstructions. TRANSLANG is the assembly language defined by the Burroughs Corporation for programming the Burroughs LSI Avionics Multiprocessor (D-machine). The FORTRAN program was modeled after a translator program written in Burroughs Compatible ALGOL. A procedure was defined for converting an ALGOL program to FORTRAN. Problems with Hollerith constants, variable initialization, character codes, and the input-output files were solved. Subprograms that duplicate the function of some ALGOL instructions requiring complex machine operations, were written. The result of this study is a translator program that performs the same function as the original ALGOL program. Numerous modifications and optimizations to the original concept, were added. The modifications include some recommended by the ALGOL programmer.

108. ANALYSIS OF PILOTED WEAPON DELIVERY: F-4E AERIAL GUNNERY

Richard H. Hackford, Jr., Capt, USAF — 86p — GGC/EE/72-3
Advisor: Maj Rankine — Lab Sponsor: AFFDL — AD 745996

Research was conducted to determine the effect of F-4E aircraft dynamics upon pilot tracking capability in the aerial gunnery mission. An example firing situation was postulated and the characteristics of the resulting lead-pursuit trajectory were determined. Mathematical representations of the aircraft; the flight control system dynamics; the fire control system dynamics, the turbulence environment, and the pilot were used to predict tracking error. The fire control system was assumed to compute the correct aimpoint, and the projectile terminal miss distance due to pilot tracking error was computed using an iterative scheme. The results of this analysis were then compared with a baseline F-4C strafing case and found to be similar in trend but greater in magnitude.

109. ANALYSIS OF PILOTED WEAPON DELIVERY: STRAFING PERFORMANCE OF A FOREIGN AIRCRAFT

William P. Hartmann, 1st Lt, USAF — 70p — GGC/EE/72-4
Advisor: Maj Rankine — Lab Sponsor: FTD — AD 745997

In order to determine whether the weapon delivery accuracy of an aircraft for which the aerodynamic stability derivatives were not known could be estimated, the strafing performance of an unspecified foreign tactical fighter was analyzed. The stability derivatives were estimated from the physical characteristics of the aircraft using standard stability and control methods. Also, by the use of classical control theory, the probable control system of the aircraft was formulated. Then, with an analytical pilot model in the aircraft's control loop, the tracking error was estimated and combined with other pilot-induced errors in a statistical model which predicts impact errors. Finally, these impact errors, the larger portion of which arose from the lateral dynamics of the aircraft, were compared with those previously determined for a U.S. tactical fighter and were found to be slightly greater.

110. A COMPARISON OF THE GRADIENT AND NEWTON-RAPHSON TECHNIQUES FOR REENTRY TRAJECTORY OPTIMIZATION

William E. Henson, Maj, USAF — 168p — GGC/EE/72-5
Gerald A. Robertson, Lt Col, USAF — Lab Sponsor: SAMS — AD 745998
Advisor: Maj Funk

This report contains a two-dimensional optimization analysis of reentry trajectories for minimization of space vehicle heating and maximization of terminal range, conducted for a lifting body reentry vehicle with a maximum lift-to-drag of three. Based on this analysis there appears to be a conflict between heat minimization and range maximization in that a high angle-of-attack is required to minimize the heating rate and a lower angle-of-attack is required to maximize range. Two optimization techniques were compared, a Newton-Raphson method and a steepest-descent gradient method. A modification of the gradient technique, which was based upon the variational Hamiltonian, was applied after convergence to a near-optimal solution, resulting in an improved control profile. Some difficulties were encountered using the Newton-Raphson method, but convergence to an optimal solution was finally achieved for a limited trajectory. The relative advantages and disadvantages of these two methods were discussed along with a complete development of each method for the specific application to the optimization of reentry trajectories.

111. ANALYSIS OF PILOTED WEAPON DELIVERY: F-4C DIVE BOMBING

Robert J. Hovde, Capt, USAF — 96p — GGC/EE/72-6
Advisor: Maj Rankine — Lab Sponsor: AFFDL — AD 745999

A model of the pilot-aircraft system is used to relate pilot tracking performance to overall weapon delivery accuracy. This permits the evaluation of the control and guidance aspects of manual weapon delivery in terms of the closed-loop parameter of impact error. All essential task problems are evaluated as integral elements of weapon delivery rather than as isolated subsystems. Specifically, a linear expression for impact error is developed in terms of the task variables directly under the pilot's control. By considering each of the pilot inputs to be a random variable, a statistical model of the propagation of the pilot-induced errors into impact errors is developed. The analysis procedure is applied to the case of F-4C dive bombing by using an analytical model of the human pilot to estimate the tracking error caused by flight control system and aircraft dynamics in the turbulence environment. Using impact point accuracy as a figure of merit, the effects of computational aids provided to the pilot and changes in control system augmentation are compared on a common scale. Unlike the case of strafing, in which a flight control change provided the greatest incremental improvement, for F-4C dive bombing the best improvement resulted from a computational aid such as a heads-up-display type of aiming device.

112. TRAJECTORY ANALYSIS OF A LUNAR VEHICLE'S RENDEZVOUS WITH A FREE-RETURN SUPPLY SHUTTLE

Robert F. Lemon, Jr., 1st Lt, USAF — 66p — GGC/EE/72-7
Advisor: Maj Funk — Lab Sponsor: AFIT

A computer program was developed which will rendezvous an ascending lunar payload, via a bielliptic transfer, with a shuttle on a free-return circumlunar trajectory. The effects of the Earth's and the Sun's gravitational

attractions on the trajectory were investigated and the results are presented for four initial payload positions. Since the velocity increment required at pericynthion for rendezvous cannot be approximated by an impulse, an implicit terminal guidance method is also presented.

113. COMPUTER RECOGNITION OF CONTINUOUS SPEECH

Kenneth R. Michael, 1st Lt, USAF — 59p — GGC/EE/72-8
Advisor: Dr. M. Kabrisky — Lab Sponsor: AFIT

Speech pattern recognition was attempted using off-line machine processes and techniques based on successful visual pattern recognition methods. The basic system used digitized data from a KY-585 Vocoder, two dimensional discrete Fourier transforms with spatial frequency filters and Wiener-Khinchin correlation. A relation to human physiology was maintained in the elementary model. A vocabulary of 5 isolated words and one continuous speech sample were studied for an identification location location decision criterion. No reliable standard was found, but a few ideas for further study were discovered.

114. ANALYSIS OF PILOTED WEAPON DELIVERY: F-4C STRAFING WITH STICK-TO-RUDDER INTERCONNECT

Thomas G. Minnich, 1st Lt, USAF — 64p — GGC/EE/72-9
Advisor: Maj Rankine — Lab Sponsor: AFFDL — AD 746000

An analysis of the pilot-aircraft system is undertaken in order to investigate weapon delivery accuracy of the McDonnell-Douglas F-4 equipment with an experimental stick-to-rudder interconnect. Pilot-vehicle analysis is used to predict the probable tracking errors in a strafing pass. These tracking errors are combined with other pilot-induced errors in a statistical model of weapon delivery in order to predict impact accuracy. The predicted errors were found to exceed those of the standard F-4. The interconnect was redesigned to minimize lateral tracking error. This redesign resulted in reduced lateral tracking error to the noise threshold level. Single-shot, gun-firing pass accuracy of the F-4 with the redesigned interconnect is compared to previously predicted and measured weapon delivery accuracy of the standard F-4. The conclusion of this paper is that the stick-to-rudder interconnect concept could be successfully employed in a multimode flight control system to improve the strafing accuracy of the standard F-4.

115. ANALYSIS OF PILOTED WEAPON DELIVERY: F-4C STRAFING WITH HIGH GAIN CONTROL AUGMENTATION

David G. Morton — 98p — GGC/EE/72-10
Advisor: Maj Rankine — Lab Sponsor: AFFDL — AD 746001

Research was undertaken to analytically predict strafing accuracy of the F-4C aircraft with an experimental high gain control augmentation system incorporated. A model of the pilot-aircraft is formulated which relates pilot tracking performance to overall strafing accuracy. This model permits realistic determination of the essential flight control system dynamic performance characteristics. Projectile impact error is expressed in terms of errors in the task variables which are directly under the pilot's control. Mathematical representations of the aircraft, the

control system dynamics, the turbulence environment, and the human pilot are used to estimate the tracking error contribution. The impact errors of the TWeaD aircraft are compared with those previously determined for the standard F-4C aircraft and are found to be just slightly less. A design criterion for any future modifications intended to improve strafing accuracy is given.

116. ANALYSIS OF PILOTED WEAPON DELIVERY: A-7D STRAFING

Timothy J. Nickerson, 1st Lt, USAF — 90p — GGC/EE/72-11
Advisor: Maj Rankine — Lab Sponsor: AFFDL — AD 746002

This study uses a unified pilot-vehicle analysis procedure to analyze the impact errors associated with a high speed, low altitude strafing pass of the A-7D aircraft. The head-up display of the A-7D is compared to the standby reticle to determine the effects of the display of tracking performance. The approach taken is to derive a linear expression of impact error in terms of errors in the task variables which are directly controlled by the pilot. By assuming each of the pilot inputs to be a random variable a statistical model for the propagation of pilot-induced errors into impact error is developed. Analytical models of the human pilot, aircraft dynamics, flight control system, and sight-display dynamics are used to estimate the tracking error resulting from the effects of turbulence. The study disclosed that tracking error is the dominating effect on impact error and that the head-up display has little effect on tracking performance. The predicted results agreed favorably with the results of a six-degree-of-freedom, piloted simulation conducted by the Boeing Company.

117. MULTI-WAFER PLASMA ANODIZATION

William B. Orcutt, 1st Lt, USAF — 67p — GGC/EE/72-12
Advisor: Capt Owen — Lab Sponsor: AFAL — AD 746003

A prototype multi-wafer plasma anodization apparatus was designed and constructed to investigate the multi-wafer process. The apparatus uses a hot hollow cathode to generate a dense discharge capable of yielding high oxide growth rates. The samples are placed parallel to the axis of the discharge in order to study the effects on oxide growth and quality of sample position with respect to discharge regions. Plasma and anodization parameters were varied to study the effect on oxide growth rates. The quality of the tantalum oxide samples was determined by visual and microscopic inspection of surfaces and by plotting capacitance and dissipation factor profiles. Results indicate that the multi-wafer process is feasible and that samples should be placed in the positive column of the discharge near the anode. The plasma should be operated near 50 mTorr at a current of approximately 4 amperes. Samples should be anodized under constant current conditions at a current of approximately 40 ma.

118. A STUDY OF OPTICAL EDGE ENHANCEMENT WITH INCOHERENT LIGHT AND ELECTRONIC EDGE ENHANCEMENT AS A POSSIBLE VISUAL PROTHESIS FOR MULTIPLE SCLEROSIS PATIENTS

David P. Payne, 1st Lt, USAF — 101p — GGC/EE/72-14
Advisor: Dr. M. Kabrisky — Lab Sponsor: AMRL — AD 746004

The purpose of this investigation is to study the effects of multiple sclerosis on the human visual system and perform a preliminary analysis for a possible prosthetic device. Optical and electronic edge enhancement were studied as a possible solution for blurred vision due to demyelination of the optic nerve. A theoretical study was undertaken for optical edge enhancement with incoherent light. An experimental approach, however, was used with electronic edge enhancement. Multiple sclerosis subjects were tested along with a controlled group for visual acuity improvement. It is hoped this work will stimulate others into applying their knowledgeable fields of interest towards possible prosthesis development.

119. ATMOSPHERIC BRAKING FOR RENDEZVOUS OF INTERPLANETARY VEHICLES WITH AN EARTH-ORBITING SPACE STATION

Aloysius J. Schneider, 1st Lt,USAF — 74p — GGC/EE/72-15
Advisor: Maj Funk — Lab Sponsor: SAMS — AD 745998

A technique is developed for achieving rendezvous between a returning lunar or interplanetary vehicle and an earth-orbiting space station. Two skips in the atmosphere are used for deceleration and for rendezvous timing. During each skip, lateral lift is applied in a manner calculated to minimize the inclination angle between the orbital planes of the returning vehicle and the space station. The sensitivity of the rendezvous timing and of the inclination angle minimization to errors and perturbations is investigated. A compensation method using rocket thrust is developed to achieve rendezvous in the presence of errors and perturbations.

120. APPLICATION OF SUB-OPTIMAL CONTROL TO MISSILE INTERCEPT PROBLEMS

Edward F. Stafford, Capt, USAF — 123p — GGC/EE/72-16
Advisor: Maj D. H. deDoes — Lab Sponsor: ASD — AD 746005

This study was to determine the feasibility of applying sub-optimal control to synthesize a feedback controller for the two-dimensional, nonlinear, air-to-air intercept and pursuit-evasion problems. A number of the sub-optimal techniques were investigated, but only one was determined to be applicable to the intercept problem. The selected method is based upon the linearization of the system dynamics, and then the sub-optimal control law is determined using conventional optimal control. Further, the solution procedure is repeated periodically, since the linear model is assumed representative of the actual system for short periods of time. Results for accelerating and non-accelerating maneuvering targets, illustrate that acceptable miss distances can be achieved. The burn rate control schedule exhibited an impulsive behavior that is attributed to the fixed time nature of the problem. The side force control behavior is dependent on the target maneuver and the initial miss alignment in target and missile

headings. Results of varying the adaptive cycle length and inserting a magnitude limiter on the thrust control are also presented. For linear target maneuvers, the sub-optimal solution is shown to more closely approximate the open loop optimal; but for nonlinear maneuvers, up to 20% of the difference can be attributed to the lack of information on the target's future maneuver. Application of the sub-optimal method to the pursuit-evasion problem is shown to be of limited value, with successful operation occurring only when the pursuer is more maneuverable than the evader.

121. UTILIZATION OF SNOBOL FOR SYNTHESIS OF LINEAR TIME-VARYING SYSTEMS

Paul G. Stokholm, Capt, USAF — 208p — GGC/EE/72-17
Advisor: Dr. G. Lamont — Lab Sponsor: ASD — AD 746006

A SNOBOL4 program has been written which synthesizes the class of linear time-varying systems whose impulse response can be described by polynomials. The program is the computer implementation of a synthesis algorithm developed by L. M. Silverman and H. Meadows. The program is written in SNOBOL4, a string manipulation language developed by Bell Telephone Laboratories, which is well suited for symbolic mathematics. The synthesis of linear time-varying systems which are described analytically involves the manipulation of algebraic functions in symbolic form; consequently, a system capable of performing algebraic and matric operations was required. The ALGEBRA I language, which was designed at the University of Minnesota in 1969 for the symbolic manipulation of polynomials and rational functions, provided a basis for the ALGEBRA II system used in this thesis. The ALGEBRA II system provides the algebraic and matric manipulation routines utilized by the Synthesis Program. The Synthesis Program has been designed so that it can be used by engineers who are unfamiliar with the SNOBOL4 language. The ALGEBRA II system, on the other hand, affords the SNOBOL4 programmer the additional capability of symbolic algebraic and matric manipulation. Users manuals for the Synthesis Program and the ALGEBRA II system, as well as example programs, have been included in the report.

122. AN INVESTIGATION OF THE SYNCODER AS A PULSE-INTERVAL PROCESSING DEVICE

Richard B. Zellmer, 1st Lt, USAF — 91p — GGC/EE/72-19
Advisor: Lt Col R. A. Hannen — Lab Sponsor: AMRL — AD 746007

An investigation of a neural model called the syncoder is performed in which a syncoder design, operation, and interconnected networks are reviewed. A regular rectangular-wave pulse train is used as a simulated neural pulse train, and a syncoder network capable of discriminating between temporally adjacent pulses is presented. This temporal discrimination device is then modified to create an interpulse interval recognition network capable of identifying rectangular wave interpulse intervals in the range 2×10^{-3} to 40×10^{-3} seconds. A syncoder network capable of detecting a simple pulse sequence defined by both spatial and temporal aspects of pulse occurrence is also developed. Finally, a conjectural scheme is suggested by which such interpulse interval and sequence detection devices might be combined to perform elementary neural information processing.

123. A METHOD FOR CALCULATING AIRCREW RADIATION DOSE

John A. Bachman, Capt, USAF — 87p — GNE/PH/72-1
Advisor: Dr. C. J. Bridgman — Lab Sponsor: SAMSO — AD 745084

A method was developed to estimate the radiation dose received by an aircrew member in an aircraft in the vicinity of an atmospheric nuclear weapon detonation. The problem is segmented into three parts; determining the radiation field at the aircraft, determining the radiation field within the aircraft, and calculating the radiation dose absorbed by the crew member. The first (air attenuation) and the third (body attenuation and energy absorption) parts have been extensively studied by others and their results are used, with some modifications. Specifically the air portion is solved using the computer code SMAUG with some special treatment of the results, and existing fluence-to-dose conversion factors are used for calculating the crew member dose. The treatment of the aircraft attenuation is developed here. The aircraft is modeled in cylindrical geometry with a homogeneous mixture of aircraft and fuel elements. The fluence is calculated by separating the scattered and non-scattered fluences. The non-scattered fluence is solved directly. The scattered fluence is determined using multigroup diffusion theory. The actual computation is attempted using a Fortran language digital computer program. Prompt neutrons and gamma-rays are considered in all segments, and an estimate of the fission product gamma-rays is also made. A sample problem is presented using the F-102A interceptor and a hypothetical burst.

124. HEAT TRANSFER COEFFICIENTS FOR TWO-PHASE (WATER/AIR) FLOW OVER A TUBE BANK

Raymond A. Carpenter, 1st Lt, USAF — 70p — GNE/PH/72-2
Advisor: Dr. B. Kaplan — Lab Sponsor: ARL — AD 744816

Local heat and mass transfer coefficients were determined for a range of mass flux ratios and spray-water injection temperatures which included 0.060 to 0.167 at 125°F, 0.069 to 0.250 at 140°F, and 0.060 to 0.203 at 160°F. The air Reynolds numbers during these tests were in the range 20,000 to 25,000. These Reynolds numbers were based on the minimum flow area within the tube bank and the tube outer diameter. An average overall heat transfer coefficient of 13.88 Btu/hr-°F-ft^2 was determined at a tubeside mass flow rate of 5491 lbm/hr and initial tubeside temperatures of 125°F and 140°F. The components of the overall heat transfer coefficients are reported for each case investigated. A total heat transfer coefficient and heat transfer amplification factor are defined and reported as functions of mass flux ratios. The maximum amplification factor was 6.22 at an air Reynolds number of 20,200 and mass flux ratio at 0.17.

125. CSSANE, A CODE FOR SYSTEM SURVIVABILITY ANALYSIS - NUCLEAR EFFECTS

Robert G. DeRaad, Capt, USAF — 107p — GNE/PH/72-3
Advisor: Dr. C. J. Bridgman — Lab Sponsor: AFWL — AD 746020

A computer code has been written to determine aerospace system survivability to selected nuclear effects. A special case of survivability is treated in which system survival is based on a comparison of the sure-kill vulnerability level and the computed free field nuclear effects levels. The code consists of two functional parts. One part is the guiding program which conducts the survivability study; the other part consists of individual subroutines which evaluate free field nuclear environment levels. Subroutines have been included to evaluate the blast and thermal environments. At a later date, subroutines will be added to evaluate the effects levels for x-ray, gamma ray, neutrons, and EMP. The present code is capable of handling from one to ten nuclear bursts and up to 100 similar vehicles in a single program run. Any type of system may be treated for which the effects vulnerability levels are known. The code has been written in the FORTRAN EXTENDED language for a CDC 6600 computer with a scope 3.3 compiler. Central core memory required is approximately 40,000 octal words and run times are on the order of seconds. A sample problem has been included to illustrate the type of study that may be performed and to demonstrate the use of the program.

126. THE DESIGN, DEVELOPMENT AND TESTING OF AN AUTOMATED SYSTEM FOR FAST NEUTRON ACTIVATION ANALYSIS

Dennis L. Downing, Lt, USAF — 131p — GNE/PH/72-4
Advisor: Dr. G. Hagee — Lab Sponsor: AFIT — AD 748420

An automated system was designed, built, and tested which is capable of the analysis of materials by activation with 14 Mev neutrons. This system was assembled at the Air Force Institute of Technology's School of Engineering at Wright-Patterson AFB, Ohio. It uses a 150 Kev Cock-croft Walton accelerator for the production of neutrons, a pneumatic system for the rapid transfer of samples, and a sodium iodide scintillation detector for counting samples. The system was tested by performing activation analyses of aluminum and concrete samples, and a computer program was written which theoretically predicts the spectrum which would result from the activation analyses of any material.

127. NEUTRON ELASTIC SCATTERING CROSS-SECTIONS FOR CARBON AT 9 MeV

Eugene C. Hart, Capt, USAF — 68p — GNE/PH/72-5
Advisor: Dr. G. Hagee — Lab Sponsor: ARL

Elastic scattering cross-sections for carbon were measured, using 9 MeV neutrons. Standard time-of-flight techniques were used. Scattering angles used varied from 30° to 162.9°. The experimental data were fitted with polynomials and are consistent with other data in the literature. Total elastic cross-section was found to be 706.9 millibarns, with an accuracy better than 5%. A theoretical calculation, based on the optical model, was also made. Results obtained with this model are in agreement with the experimental data. These results give insight into the depths of the potential well and other potentials for carbon. It is recommended that further experiments be conducted to gather data on the carbon elastic scattering cross-sections in the 7 to 14 MeV range.

128. ELEMENTAL AND TRACE ANALYSIS BY ENERGY-DISPERSIVE X-RAY SPECTROMETRY

John M. Hockemeier, Capt, USAF — 52p — GNE/PH/72-6
Advisor: Dr. G. Hagee — Lab Sponsor: AFIT — AD 748421

In this study energy-dispersive X-ray spectrometry is examined as an analytical tool for elemental and trace quantity analysis. Characteristic X-rays are generated in samples by gamma and X-ray emitting radioisotopes and by high energy protons. Quantitative analysis, based upon empirical techniques derived from wavelength-dispersion methods gives elemental composition values to within approximately 1% of chemically analyzed standards. In proton activation of X-rays empirical equations and experimentals values result in actual detection of trace quantities of elements to the nanogram level. Extrapolations of detected values indicate that the method is capable of detecting quantities to the picogram level. A vacuum chamber, designed, built and adapted to a 2 MeV Van de Graaff accelerator is used as the target chamber. The targets are thin (200 $\mu gm/cm^2$) carbon foils on which are deposited the specimens under investigation. An atmospheric sample is a typical specimen examined. Trace quantities of elements such as bromine, lead, mercury, gallium and others are detected in the nanogram range.

129. PHOTOLUMINESCENCE STUDIES OF GERMANIUM USING A NEODYMIUM LASER

Steven B. Humbert, Capt, USAF — 79p — GNE/PH/72-7
Advisor: Lt Col J. DeWitt — Lab Sponsor: AFML — AD 743566

Irradiated and non-irradiated germanium samples were studied at liquid He temperatures with the technique of photoluminescence produced by a commercial NdYAG laser. In a continuous mode, the laser was used with conventional lock-in amplifier techniques to obtain luminescence intensity vs energy spectra and in a pulsed mode the laser was used with a boxcar integrator to obtain both energy spectra and recombination lifetime data. Intrinsic band-to-band spectra were studied with the laser in either the continuous pulsed modes while extrinsic radiation defect spectra could not be observed in the pulsed mode. Continuous laser excitation produced intrinsic band gap and extrinsic defect spectra that were identical to previous results using a high intensity tungsten lamp as the excitation source. The intrinsic spectra were shifted 4.3 MeV lower (long-wavelength spectra) in the pulsed mode than in the continuous mode. This shift was attributed to the condensation of excitons resulting from high excess carrier densities generated by the laser. A value of 12 microseconds for the luminescence lifetime of the long-wavelength spectra was obtained and found to compare favorably with other experimental values in the literature.

130. A CODE FOR AIRCRAFT SURVIVABILITY ANALYSIS - GAMMA AND NEUTRON EFFECTS

Robert D. McLaren, Capt, USAF — 142p — GNE/PH/72-8
Advisor: Dr. C. J. Bridgman — Lab Sponsor: AFWL — AD 746051

This report presents a code, developed by the author, that predicts neutron and gamma fluences (or doses), including neutron induced gammas, in an exponential atmosphere for burst altitudes between 7 and 100 kilometers.

The problem was solved by using the diffusion equation, with separation of virgin and scattered particles, in a nonorthogonal coordinate system. The diffusion equation in this coordinate system was approximated by a nine point difference equation and the resulting matrix equation was solved by use of a block tri-diagonal algorithm. The resulting computer code, in FORTRAN Extended, was written to calculate the survivability of up to 100 aircraft or space vehicles in addition to the calculation of fluences (doses). The code requires 20 minutes of central processor time and one hour of input/output time on the Wright-Patterson Air Force Base CDC 6600 computer. The results of this code for a burst at 25 km are compared to those obtained from a constant density atmospheric model and from charts based on SMAUG which employs mass integral scaling. Significant differences are noted for the case where the burst and receiver are at the same altitude, which casts some doubt on the validity of mass integral scaling at this altitude.

131. A MODEL FOR THE EARLY TIME ELECTROMAGNETIC PULSE FROM A HIGH ALTITUDE NUCLEAR EXPLOSION

Laramie D. Starling, Maj, USAF — 46p — GNE/PH/72-9
Advisor: Dr. C. J. Bridgman — Lab Sponsor: AFWL

A simple analytical model is developed to describe the electromagnetic pulse (EMP) from a high altitude nuclear explosion from onset to peak. The analysis of the problem is simplified by assuming, monoenergetic gamma rays only, exponential atmosphere, all contributions to EMP come from source elements very close to line-of-sight between burst and observer, all the gammas are absorbed in a thin layer of atmosphere below the burst, Compton current dominates over all other effects in the source region, Compton current is spatial constant over the portion of the source region which contributes to EMP at a specific point. The model used is a sheet of time varying currents, transverse to the line-of-sight, and located at the maximum gamma ray interaction height. The EMP from a hypothetical nuclear explosion is calculated using this model. Results closely agree with values available in the unclassified literature.

132. AN INVESTIGATION OF NUMERICAL METHODS FOR OBTAINING GREEN'S FUNCTIONS

Jack L. Tills, Capt, USAF — 58p — GNE/PH/72-10
Advisor: Dr. B. Kaplan — Lab Sponsor: AFIT — AD 743619

This study was devoted to obtaining an optimal numerical method for computing discrete Green's functions for the Laplacian operator. Two competitive numerical methods were employed: successive over-relaxation and a modified Monte Carlo method, the Exodus method. Green's functions were computed for square and cubic grids. Comparisons were made on the basis of accuracy and required computation time. Accuracy was determined by comparing numerical Green's functions with analytical solutions. Both methods, iterative and statistical, gave comparable accuracy results. Required computation times for the successive over-relaxation method were consistently less than the Exodus method. For all regions considered, both planar and volumetric, the successive over-relaxation method was found to be the optimal numerical method for determining Green's functions accurately and rapidly.

133. ZERO-PHONON LINE ABSORPTION SPECTRA OF RADIATION DAMAGE CENTERS IN SILICON

Kennedy B. Wilson, Capt, USAF — 94p — GNE/PH/72-11
Advisor: Lt Col J. DeWitt — Lab Sponsor: AFML — AD 743987

Infrared absorption measurements were made for n-type silicon samples irradiated with 1 MeV electrons at room temperatures. The absorption spectra in the range 1-3 microns were recorded at both liquid nitrogen and liquid helium temperatures. Three families of zero-phonon lines and phonon-assisted sideband structure were seen which correspond to those seen in luminescence spectra. The families at 0.4891 eV and 0.7898 eV were seen only in pulled samples, while the family at 0.9702 eV was seen in both pulled and float-zone samples. A dose rate study indicated that all three families are independent of each other. The zero-phonon lines at 0.7898 eV, 0.7948 eV, and 0.9702 eV are independent of the divacancy. The growth rate of the line at 0.4891 eV may follow that of the divacancy. The splitting of the zero-phonon line at 0.7898 eV occurs in the excited state since both the zero-phonon lines at 0.7898 eV and 0.7948 eV occurred at equal intensity in the low temperature absorption spectra.

134. A SUPPLEMENT TO HAIGHT'S "INDEX TO THE DISTRIBUTIONS OF MATHEMATICAL STATISTICS" WITH A DISCUSSION OF THE UNIFORM DISTRIBUTION AND SOME RELATED DISTRIBUTIONS

Otto L. Buss, Jr., Capt, USAF — 80p — GSA/MA/72-2
Advisor: Dr. D. Barr — Lab Sponsor: AFIT — AD 743614

A supplement to Frank A. Haight's "Index to the Distributions of Mathematical Statistics" is presented along with an illustration of its usefulness. It is a partial update, covering articles from Biometrika, January 1958 to December 1967, adding to the work of Joseph L. Rhodes, Jr. The index's usefulness in aiding the researcher is illustrated by the researching of the uniform distribution defined on the intervals (0,1), (a-h, a+h), and (0,a) along with three distributions closely related to the uniform (rectangular sum, Bates, and Stevens-Fisher) starting with the reference given in Haight's Index.

135. ROBUST ESTIMATION TECHNIQUES FOR LOCATION PARAMETER ESTIMATION OF SYMMETRIC DISTRIBUTIONS

John Caso, Capt, USAF — 103p — GSA/MA/72-3
Advisor: Prof H. Moore — Lab Sponsor: ARL — AD 744695

Several robust estimators are considered for analysis and explanation. Monte Carlo techniques are used to investigate the efficiency of these robust estimators relative to the best estimator for the distribution under consideration. Sample sizes of 12 and 24 were drawn 4200 times from five symmetric probability distributions. The results show that over a class of distributions the robust estimators provide a higher guaranteed efficiency than the best estimator for any particular distribution in the family. Some interesting results are apparent from an analysis of the graphs in Appendix C indicating some upper bounds on the size of the Monte Carlo sample when conducting this type of study.

136. A COMPARISON OF THE RIEMANN AND LEBESGUE INTEGRATION THEORIES

Charles T. Clark, Capt, USAF — 101p — GSA/MA/72-4
Advisor: Capt Oliver — Lab Sponsor: AFIT — AD 743316

The treatment of Riemann integration presently found in the literature does not adequately describe the class of functions to which the concept of Riemann integration can be applied. Also, no adequate comparison of Riemann and Lebesgue integration theories exists in the literature. The second chapter in this thesis provides criteria for determining whether the Riemann integral of a function over an interval assumes a finite value. The third chapter reviews important facts concerning the class of Lebesgue integrable functions. In the final chapter Riemann and Lebesgue integration are compared.

137. DENTAL CLINIC SCHEDULING - A SIMULATION APPROACH

William H. Glendenning, Maj,USAF — 174p — GSA/SM/72-5
Advisor: Maj R. J. Quayle — Lab Sponsor: AFHRL — AD 741450

The dentists working in the restorative section of the Dental Clinic at the Wright-Patterson AFB Medical Center were frequently incurring large amounts of idle time. The Dental Clinic utilized an Individual appointment system with patients scheduled for either a 45 minute or a 90 minute appointment. The inflexibility of this type appointment scheduling system contributed to the amount of dentist idle time incurred. Two different simulation models (which utilized patient arrival time, restorative service time and the dentists' estimate of the service time required for each patient) were developed to enable experimentation with several different type appointment systems. Appointment system D, which provides available appointment lenghts of 30, 45, 60, 75 and 90 minutes, is recommended for all follow-up appointments. This is an individual appointment system which will allow each patient to be serviced by the same dentist until all required work has been completed. Appointment system Y, which schedules a specific number of 30, 45 and 60 minute appointments during each clinic session, is recommended for patients scheduled for their first appointment. This is a Mixed Block-Individual appointment system in which each patient's first appointment length is based on the examining dentists' estimate of the service time required for the patient's first appointment. The patients are not scheduled with a specific dentist and are serviced on an earliest arrival time basis. Initiating these two systems requires scheduling patients for follow-up appointments during different clinic sessions than those scheduled for their initial appointments. Initiation of these two appointment systems will result in approximately a 25% increase in the number of patients scheduled with an associated average patient waiting time and average dentist idle time of less than 17 minutes.

138. THE IDENTIFICATION OF LINEAR STOCHASTIC SYSTEMS

Adolph Harris — 106p — GSA/MA/72-5
Advisor: Dr. D. R. Barr — Lab Sponsor: AFIT — AD 741437

This research considers the problem of the identification of linear stochastic systems. A current state-of-the-art assessment of the general field of system identification is given, and criteria for the classification and selection of identification methods are presented and discussed. Several

of the more popular identification methods from the literature are investigated and summarized. A bibliography containing 185 references, keyed by identification methods and other relevant headings, is included. Using the state variable formulation for a discrete linear stochastic system, a detailed exposition of a few of the on-line identification methods currently appearing in the literature is presented. One such method, based on the autocorrelation function of the output measurements, is developed to identify the state transition matrix and the output noise covariance (vector-input, scalar-output case). It is shown that a canonical or phase variable system representation can be used to reduce the number of unknown parameters requiring identification. Finally, an on-line identification method called Levy's proper canonical form, which is based on the Kalman filter representation of the system, is derived using the innovations sequence and certain results from optimal estimation theory. It is shown that this identification method results in still additional advantages over the identification methods previously developed.

139. PLANNING-PROGRAMMING-BUDGETING CONCEPTS APPLIED TO PUBLIC SCHOOL DISTRICT FINANCIAL MANAGEMENT

Leland G. Jordan, Capt, USAF — 265p — GSA/SM/72-7
James L. Weaver, Capt, USAF — Lab Sponsor: AFIT — AD 741409
Advisor: Lt Col C. J. Doryland

The rising cost of public education and the resulting pressures for higher local property tax rates have caused the financial management of public schools to come under increased scrutiny. The study applies Planning-Programming-Budgeting Systems (PPBS) to school district financial management. The adaptation of PPBS to a public school district is difficult, but the problems are not insurmountable. A school district PPBS should include a statement of objectives, and a program structure which relates all resource-consuming activities to those objectives. It should also include estimating relationships that model the future economic environment of the district. These relationships should provide for estimating total costs of various spending alternatives, and allow trade-off analyses to be made between costs and effectiveness. This study applies PPBS concepts to the Northmont Local School District, Dayton, Ohio. Methodologies are presented for eliciting a statement of district objectives, designing a program structure, and deriving the estimating relationships. A prototype PPBS is tested and exercised on a Monte-Carlo computer simulation model of the Northmont economic environment. The research reveals some significant implications of PPBS for public school districts, including revised financial records, greater delegation of authority, specific position authorizations, and major organizational realignments.

140. A LANCHESTER MODEL FOR AIR BATTLES

John H. Latchaw, Capt, USAF — 78p — GSA/SM/72-8
Advisor: Dr. H. Enzer — Lab Sponsor: AFSA — AD 741412

A historical verification, comparing data with model predictions, was made between the results of three World War II bombing missions and the outcome which was obtained by allowing an analytical model to "replay" the battles.

The model used to predict bomber force size as a function of time was a closed form solution for a set of differential equations which correspond to Frederick Lanchester's Square Law of combat. An attempt to measure the quality of the model was made by arbitrarily considering a prediction to be "accurate" if it was within two per cent of the known force size value. The initial comparison results did not fall into the "accurate" category but successive improvements were made by considering two variations. The first change involved the assumption that the act of a bomber repelling an attacker had a detrimental effect on fighter aircraft effectiveness. The second alteration incorporated the assumption that the effectiveness of both bomber and fighter aircraft varied throughout the battle. This second modification produced predictions which were "accurate" during 90% of a given engagement. Finally, a battle which included a relatively large number of bomber losses caused by ground fire was studied. A variation of the original model was used to "replay" this mission to illustrate the flexibility of the model.

141. A MAINTENANCE MANHOUR SENSITIVITY MODEL FOR CARGO AIRCRAFT

Terry R. Little, Capt, USAF — 122p — GSA/SM/72-9
Advisor: Dr. H. Enzer — Lab Sponsor: AFLC — AD 741410

A statistical study, based on one year's historical data, was made on the effects of certain policy changes on both cargo aircraft maintenance manhours and aircraft out-of-commission time. The results indicated that manhours was highly sensitive to flying hours, but not in constant proportion as implied in the generally used term, manhours/flying hour. Sortie length and number of landings per sortie have no apparent effects on manhours, judging from the sample data. It was further discovered that manhour changes may be expected if an aircraft is deployed either to Pacific Air Forces or Reserve/Guard units. Further manhours were found to be highly correlated with aircraft complexity as primarily measured by aircraft empty weight. The analysis showed that aircraft out-of-commission time may be expected to remain unchanged with changes in how the aircraft is used. This result, taken with the conclusion that manhours do change with changes in aircraft utilization, suggests that mechanics are forced to adjust to increased workload by working longer and faster; in effect, Air Force policy allows maintenance labor to be treated as if it had no cost.

142. A CASE STUDY IN SYSTEMS ANALYSIS

Clifford Miller — 112p — GSA/SM/72-10
Advisor: Lt Col C. J. Doryland — Lab Sponsor: AFIT — AD 741413

This thesis contains a case study in systems analysis, designed specifically for use in the Graduate Systems Analysis program at the Air Force Institute of Technology. The case study was based on an analysis performed in the office of the Air Force Chief of Operations Analysis (since merged with the office of the Air Force Assistant Chief of Staff for Studies and Analysis, under that title). The case study concerns a coastal radar bomb scoring practice route belonging to Strategic Air Command, which passes close to a commercial nuclear power facility. When a B-52 crashes on the practice route in the proximity of the power plant, interest is suddenly focussed on the possibility of a B-52 crashing into the plant, and the consequences of such a crash. The case study presents the views of several interested parties. An analysis of the problem is then presented, from the viewpoint of an analyst at the level of the headquarters, United States Air Force. The completely

assembled case study, with its accompanying teaching notes, was tested in the classroom through the cooperation of a group of fifteen Graduate Systems Analysis students. The core of the classroom test was a non-parametric statistical analysis to determine if the case study effectively taught a pre-defined tenet of the current doctrine in systems analysis. Several tests performed on the corrected data gave unanimous affirmation that the case study was effective in meeting this specific, carefully defined teaching objective.

143. A DUAL INDUSTRY ANALYSIS TO GIVE PERSPECTIVE TO AEROSPACE DEFENSE INDUSTRY PROFITS

Michael J. Mruz, Capt, USAF — 117p — GSA/SM/72-11
Advisor: Lt Col Belden — Lab Sponsor: AFIT — AD 741411

This study examines the aggregate profit rates of various samples of aerospace defense contractors within the particular operating environment of the defense and space systems market. To give perspective to this particular operating environment, a parallel study of the public utility industry and its operating environment is also included. The analysis includes a detailed examination of return indices for both industries and a comprehensive description of the particular industry operating environments. The elements of the operating environments studies are capital investment, research and development, demand, competition, and regulation and contracts. On an aggregate basis, the study concludes that the return rates for the public utility and aerospace defense industries are not dramatically different, either in magnitude or trend, and that when these rates are considered within the perspective of the operating environments described in the study, the aerospace defense industry's "return on operating environment" is not unlike that achieved by the public utility industry.

144. DETERMINATION AND COMPARISON OF OBJECTIVES IN A SCHOOL DISTRICT

Gary W. Pfeifer, Capt, USAF — 115p — GSA/SM/72-12
Advisor: Lt Col C. J. Doryland — Lab Sponsor: AFIT — AD 741452

This research was undertaken in an effort to discover the relation of the objectives of various levels of a school district. The research was limited to the high school, school district staff and board of education. A modification of the Delphi process was used to elicit objectives from the various levels researched. This modification was made partly to accommodate the process to the elicitation of objectives. The modification also included an initial list, inspired by the SEER modification to Delphi, procedures to ease the pressure toward convergence of opinion, and a requirement for the panelists to rank the objectives which they selected. Once the objectives were developed, they were classified by central theme and matched from level to level. A comparison of the ranked matchings from one level to the next was used to determine if the objectives were related. Specifically, the Spearman Rank Correlation Coefficient test was used to determine if the rankings of objectives were related from one level to the next. The findings showed that, at a significance level of .05, the only case of ranking of objectives being related was between the high school department objectives and the high school staff objectives. An additional finding was that the correlation coefficients were higher for adjacent levels in the school district than for nonadjacent levels.

145. A FORTRAN PROGRAM FOR AN EXACT TEST OF INDEPENDENCE IN AN M x N CONTINGENCY TABLE

Marvin F. Schwartz, Jr., Maj, USAF 55p GSA/MA/72-6
Advisor: Dr. D. R. Barr Lab Sponsor: AFIT AD 743613

General m x n contingency tables are discussed along with relationships common to all such tables. The background for various probability models is presented as well as the theory for a general conditional test. The general test is then applied specifically to the probability model selected followed by a numerical example. A brief history of past efforts in computing the exact test is provided. Finally, the major portions of the FORTRAN program are presented along with some illustrative examples. The final program is included as a useful entity.

146. MICROWAVE ILS SCANNING BEAM DATA RATE ANALYSIS APPLIED TO THE CH-53A HELICOPTER

Paul R. Stolz, Capt, USAF 101p GSA/MA/72-18
Advisor: Maj J. D. Dillow Lab Sponsor: AFFDL AD 743612

Data rate requirements for low visibility approach with a sample data measurement glideslope deviation was investigated analytically using CH-53A helicopter dynamics. A "window" was defined by specifying certain allowable deviations in the aircraft motion variables which are acceptable for continuation of the landing at a 100 ft decision altitude. The approach performance was defined as the probability of missing the window, which corresponds to the probability of a missed approach. The landing approach process was modeled by a system of stochastic differential equations which account for the aircraft dynamics, atmospheric disturbances, guidance errors and data rate. The flight control system was modeled by a state estimator and a state feedback matrix which was optimized so as to minimize the probability of a missed approach subject to rms constraints on control activity. Variations considered in the model include gust environment, guidance errors, control authority, and onboard sensors. For each case considered, the performance degradation due to data rate was computed and plotted. Based on the "allowable" degradation in performance from that obtainable with continuously measured glideslope deviation, the data rate requirements can be determined. The study reveals that the flight control system is the limiting factor in achieving an all weather Category II low visibility landing capability with a state of the art scanning beam guidance system and data rates about 6 samples/sec. This is due to the requirements to suppress gust upset. The trade offs between the flight control system and scanning beam guidance system data rate requirements are illustrated by comparing the results for various flight control schemes. For example, data rate requirements are significantly reduced via onboard inertial measurements. However, the results indicate that a data rate between 10 and 20 samples/sec. is extremely desirable in order to fully realize the flight control system's potential for suppressing glideslope tracking errors due to gust upset if onboard inertial sensors are not used.

147. FORSTRAN - A CASE IN FORCE STRUCTURE ANALYSIS

David K. Stubbs, Capt, USAF 120p GSA/SM/72-14
Advisor: Lt Col C. J. Doryland Lab Sponsor: AFIT AD 741449

There has been considerable emphasis recently on analysis (systems, economic, cost-benefit, etc.) in government decision-making activities. One approach

which is currently popular is the Planning-Programming-Budgeting System (PPBS). PPBS is often described as a means of helping responsible officials make decisions. The implication of the system is that it interrelates the planning, budgeting, and decision-making functions. Regardless of the name of the system presently in use, the relationships among these three management activities is of primary importance. This paper develops a methodology to aid the educational process of future decision-makers in their efforts to integrate quantitative and non-quantitative aspects bearing on planning, budgeting, and decision problems. The final product is a case study in force structure analysis (FORSTRAN). Participants are required to define the status of the current strategic retaliatory forces as described in a scenario and then make decisions as to future requirements and methods of achieving those requirements. A set of computer programs is furnished to remove the necessity of routine mathematical computation and free the student to more thoroughly consider the non-quantitative aspects of the problem. The case is an exercise in problem-finding as well as problem-solving. The report concludes that FORSTRAN does provide a viable methodology for teaching future decision-makers about the relationships developed among governmental planning, budgeting, and decision processes. The case study method of presentation is recommended for classroom use of this problem. Suggestions for further research are also offered.

148. DISTRIBUTION FREE METHODS FOR THE CHANCE-CONSTRAINED PROGRAMMING MODEL

Jon R. Thomas, Capt, USAF — 53p — GSA/SM/72-15
Advisor: Maj Agnew — Lab Sponsor: AFIT — AD 741414

This paper is concerned with the development of certainty or deterministic equivalent nonlinear programming models from chance-constrained programming models. It contains a review of some of the historical developments in this area which were made by Charnes and Cooper, Kataoka, Miller and Wagner, Hillier, and Sengupta. The paper introduces a new, distribution free approach to chance-constrained programming which can be used with both single and joint chance constraints. Finally, the distribution free chance-constrained model is applied to the economic problem of input-output analysis.

149. SEQUENTIAL INVENTORY CONTROL AND OPTIMIZATION THROUGH STOCHASTIC APPROXIMATION

Thomas R. Tower, Capt, USAF — 63p — GSA/SM/72-16
Advisor: Maj Agnew — Lab Sponsor: AFLC — AD 741451

Optimal investory policies are typically characterized by a stationary post-order inventory level S, which is the level up to which an order is placed including both inventory on hand and on order. Some Inventory systems have explicit solutions presented in the literature and others have solutions characterized by dynamic programming equations. All of these solutions require a knowledge of the distribution function for demand when it is a random variable. If we have no knowledge of the distribution function we are able to formulate certain stochastic approximation techniques which "hone-in" on the optimal policy values using observations of demands and costs as they occur.

These techniques all assure convergence in the mean square and with probability one to the optimal values. A wide range of inventory systems are treated including those in which the delivery of orders is lagged a fixed number of periods after the order is placed and those with a fixed cost associated with an order, called the setup cost. Initially, all stocks are treated as discrete integer valued products, but procedures are given for continuous values stocks such as liquids.

150. SIZE DISTRIBUTION, MERCURY/LEAD CONCENTRATIONS, AND STOCHASTIC ANALYSIS OF SUSPENDED PARTICULATES IN AMBIENT AIR

Dennis L. Brown, Capt, USAF — 77p — GSF/MC/72-1
Advisor: Lt Eastler — Lab Sponsor: AFWL — AD 748356

Particulate concentration, particle size distribution, and mercury and lead concentrations in atmospheric particulates on Wright-Patterson Air Force Base (WPAFB), Ohio, were determined. Samples were taken from three locations on WPAFB using an Anderson hi-volume sampler head mounted on a Staplex hi-volume sampler. Particulates were fractionated by the sampler head as follows: greater than 7.0, 3.3 to 7.0, 2.0 to 3.3, 1.1 to 2.0, and less than 1.1 microns in equivalent aerodynamic diameter. The distribution of the particulate concentrations was analyzed using the Reverse Arrangements test to establish randomness, the Kolmogorov-Smirnov test to compare ten proposed probability density functions with the data collected, and the Likelihood Ratio test to isolate the function best describing the data. The mean particulate concentration was 85.1ug/m^3, with a variance of 1048.2. Particulates under 1.1 microns composed an average of 31.3 per cent of the total weight, those from 1.1 to 7.0 microns made up 31.9 per cent, and those over 7.0 microns composed 36.8 per cent of the sample. The average lead concentration during a 24-hour sampling period was 1.25 ug/m^3; 50.9 per cent of the lead was found in particulates under 1.1 microns. Mercury concentrations in particulates average 6.9 ng/m^3, however, due to inconsistencies in the analytical method no correlation could be established between mercury concentration and particle size.

151. EXPERIMENTAL DETERMINATION OF PIEZOELECTRIC PARAMETERS

Glenn C. Disch, 1st Lt, USAF — 61p — GSF/MC/72-2
Advisor: Prof P. Nemergut — Lab Sponsor: NUSL — AD 748357

A theory was developed whereby the elastic compliance s^E_{11}, piezoelectric constant d_{31} and dielectric constant ε^S_{33} could all be determined by mechanically driving a transversely polarized ceramic bar. 3-port analysis was applied to longitudinal vibrations in a transversely polarized ceramic bar. Furthermore, losses were accounted for by assuming complex dissipation. Experimentation was conducted according to the developed theory using standard 3-port techniques. The zero velocity boundary condition was approximated by using quarter-wavelength glass rods. Barium titanate and lead zirconate titanate were investigated for the two to four kilohertz audio frequency band and for driving levels ranging from ten to fifty g's. Results for barium titanate compared favorably with those obtained using electric excitation. Results for lead zirconate titanate indicated that the dielectric constant and phase angles associated with the piezoelectric and dielectric constant were greater than those obtained using electrical excitation. The loss tangent for both barium titanate and lead zirconate titanate decreased with increasing mechanical driving levels. The opposite has been found for increasing levels of electric excitation.

152. EFFECTS OF UNIAXIAL RESTRAINT ON TYPE S SHRINKAGE COMPENSATING LIGHT-WEIGHT CONCRETE

Jerry S. Doughty, 1st Lt, USAF — 76p — GSF/MC/72-3
Advisor: Maj S. W. Johnson — Lab Sponsor: CES

The effects of varying amounts of unbonded, uniaxial restraint on concrete specimens prepared with Type S shrinkage compensating cement and lightweight aggregate were investigated. The amount of restraining steel varied between 0.16 and 0.61 per cent of the net concrete area. Data on compressive strengths, elastic moduli, and prestress and expansion relative to initial measurements made 18 hours after casting were collected. Transverse expansion was not measured. The results from this investigation indicated that the expansive potential is too small for variations in restraint to significantly affect the mechanical properties of shrinkage compensating Type S concretes. Specimens restrained by 0.51 percent steel yielded the highest magnitudes of prestress. Curing of Type S expansive concretes with large amounts of free water available to the surface may cause expansion to cease at an earlier age and lower value by dissolution of the sulfate content into the curing water where it can no longer supply the expansive mechanism. Information from previous investigations was used to present an explanation of the cyclic expansion behavior exhibited by restrained specimens in this study.

153. FLEXURE OF A BEAM SUPPORTED ON AN ELASTIC FOUNDATION

Ronald W. Feiken, Capt, USAF — 77p — GSF/MC/72-4
Advisor: Maj R. O. Meitz — Lab Sponsor: AFIT — AD 741453

This thesis presents a technique for analyzing the flexure of a beam supported on an elastic foundation, which does not allow normal tensile stresses at the interface, using the finite element method. The technique presented can be used in instances where the shape of the beam or foundation is irregular and where the beam or foundation is nonhomogeneous. The beam and foundation are represented by elements that have displacement functions thay vary as the third-degree of Y and the fifth-degree of X. The distance between the applied concentrated load and the point where the weightless beam lifts off the foundation is determined and compared with previous work where the lift-off distance was determined by an analytic solution using a Reissner model for the foundation. Within certain ranges of the parameters, the comparison between the two different methods is quite close. The computer program that was developed to analyze the problem is written in the Extended Fortran language for a CDC computer.

154. CORING, DESCRIPTION AND MERCURY AND LEAD ANALYSIS OF LAKE BOTTOM SEDIMENTS

Michael S. Hayner, Capt, USAF — 72p — GSF/MC/72-5
Advisor: Lt Eastler — Lab Sponsor: AFWL — AD 741436

A standardized system for procurement and testing of cores of lake bottom sediments for analysis of background and time-varying concentrations of potentially toxic materials, in particular mercury

and lead, is required to allow correlation of data from various sampling sites. Core analysis includes description of structure, texture, color, and composition, measurement of pH and Eh, and determination of mercury and lead concentrations. A simple hand-operated coring device was developed and subsequently used to obtain cores from Gravel Lake, WPAFB, Ohio. The cores obtained from Gravel Lake were then employed in the development of the test procedures. Data obtained from this study indicate no significant variations in concentrations of mercury or lead between layers in Gravel Lake, but do represent background levels for Gravel Lake and can be used as a baseline comparison for subsequent studies in the land management area at WPAFB and at other Air Force installations. Deficiencies were observed in the sampling apparatus and the mercury analysis. Modifications are suggested to improve equipment and procedures for future lake bottom sediment studies.

155. EXPERIMENTAL INVESTIGATION OF INITIAL SURFACE PARTICLE MOTION RESULTING FROM SMALL SUBSURFACE EXPLOSIONS IN DRY OTTAWA SAND

Floyd V. Kimberly, Maj, USAF — 107p — GSF/MC/72-6
Advisor: Maj S. W. Johnson — Lab Sponsor: AFWL — AD 748358

An analysis was made of the relationships of surface motion to depth of burst (DOB) for 1.7 gram, spherical charges of lead azide detonated in dry Ottawa sand. Surface motion was studied by taking high-speed movies of each test. A colored sand grid pattern was laid on the surface of the test bed, so the intersections of the pattern could provide the data points for study. The films were analyzed by using a film reader for data reduction and computer programs for curve fitting. Relationships of velocity vs. DOB, ejection angle vs. DOB, ejection angle vs. velocity, and mound growth vs. time were studied. For each equi-distant point from Surface Ground Zero (SGZ), a log-log plot of velocity versus DOB showed two connecting straight line segments with the change in slope at 30mm DOB. The slopes of the lines for points from SGZ to 50mm from SGZ changed systematically from negative to positive for DOB's down to 30mm. For depths greater than 30mm, all the slopes were sharply negative. The "break" in the curves at 30mm DOB was attributed to the change in the fole of spallation and gas acceleration for crater formation. Ejection angle increased systematically with an increase in DOB. Ejection angle vs. velocity produced a linear relationship for each equi-distant point from SGZ. The slopes of the lines decreases systematically with increasing distance from SGZ. To study mound growth, a shape factor, the ratio of height to width of the base of the mound, was determined and plotted against time. The factor varied linearly for each DOB with decreasing slope for increasing DOB. A comparison was made with a similar study which used targets on the pre-shot surface to study surface motion. The results from the two studies varied sufficiently to question the use of targets to provide an adequate analysis of surface motion.

156. EFFECT OF THERMOMECHANICAL TREATMENT ON THE STRESS CORROSION CRACKING SUSCEPTIBILITY OF BETA III TITANIUM

John H. Seats, Maj, USAF — 84p — GSF/MC/72-7
Advisor: Capt W. B. Crow — Lab Sponsor: ARL — AD 748359

This investigation was undertaken to determine the effect of thermomechanical treatment on the stress corrosion cracking (SCC) susceptibility of Beta III titanium alloy. Specimens receiving cold-working

treatments of 0, 2, 5, 10, 20, and 50% were given 8 hour precipitation hardening treatments at 900°F and subsequently subjected to stress levels of 80% of yield in a 3.5w/o NaCl at ambient temperature. An alternate wet/dry test was used to simulate actual service conditions. These tests were conducted until failure occurred or a minimum of 720 hour test time limit had elapsed. A 720 hour test time was considered sufficient to establish the degree of stress corrosion cracking susceptibility. A more severe test was performed on a small number of specimens to determine if crack initiation was a factor in stress corrosion cracking. These specimens were notched and fatigue cracked prior to testing in the corrosive environment. In the unnotched configuration and for all thermomechanical treatments, Beta III was virtually immune to SCC. Tensile failure did occur in specimens that contained machining defects. The fatigue-cracked specimens exhibited intergranular SCC, but crack propagation was too slow to cause catastrophic failure within the test period. Beta III was found to be extremely notch sensitive, especially in sections with cross-sectional areas less than 0.1 inch. Sufficient area to distribute the load is needed if specimens are to be precracked; otherwise, catastrophic failure would be predicted to occur.

157. CURING TEMPERATURE EFFECTS ON TYPE S, SHRINKAGE COMPENSATED, LIGHTWEIGHT CONCRETE

James E. Teague, Capt, USAF | 119p | GSF/MC/72-8
Advisor: Maj S. W. Johnson | Lab Sponsor: CES | AD 748360

A study was conducted to determine curing temperature effects on a restrained, shrinkage compensated, Type S, lightweight concrete. The cement content was 6.73 SCY and the aggregate was haydite. Temperatures used were 50°F, 61°F, 72°F and 93°F. The physical properties observed were expansions, compressive strengths and stress-strain relations. These data were correlated to x-ray intensity ratios for the strength-producing tobermorite and the expansion-producing ettringite. The period of observations was from 0 to 28 days. Results from the twenty-eighth day showed that compared to the 50°F variation, the 93°F variation was 68% stronger, had a 25% increase in the 45% secant modulus, a 26% decrease in ultimate strain under rapid loading and a increase in the magnitude of expansion of 0.0373% strain. No optimum temperature was found for either strength or expansion. Tobermorite intensity ratios were shown to be directly related to the strength properties but no firm conclusions could be reached regarding ettringite and expansion relationships due to the poor consistency of $Na_2WO_4 \cdot 2H_2O$ as an internal standard. Increased expansions with increased temperature were shown to decrease the corresponding amount of strength gain for time periods between 3 to 14 days.

158. AN ANALYSIS OF MANAGEMENT PRACTICES APPLIED TO THE RESEARCH AND DEVELOPMENT OF AIR-TO-AIR MISSILES

Herbert Altman, Capt, USAF — 96p — GSM/SM/72-1
Advisor: Maj T. R. Manley — Lab Sponsor: AFAL

This thesis analyzes the management practices of the Air Force and Navy in the RDT&E of air-to-air missiles and examines the practicality of joint service development. The project originated out of the decision to appoint the Navy executive service for joint air-to-air missile development and the reservations on the part of some Air Force personnel concerning the ability of the Navy to satisfy the operational needs of the Air Force. It was found that the RDT&E effort at ADTC was hampered by a lack of role definition overreliance on functional management orientation. China Lake NWC is characterized by high personal motivation and goal orientation brought about by the flexible application of management practices, in particular the degree of autonomy granted the project team. The AIM-9L project, an example of joint service development, uses a dual deputy management organization backed by a singular chain of responsibility to isolate the team members from the pressures of interservice rivalry. AF needs have been met on this project. With modifications stipulated within this report, the AIM-9L organization can possibly serve as a model for future joint service RDT&E. The primary considerations for such projects are avoidance of parochialism and application of the systems concept, especially in regard to continuity of expertise throughout the life cycle of any program.

159. AN ANALYSIS OF MILITARY AIRLIFT COMMAND EFFORTS TO IMPROVE PLANNING AND EMPLOYMENT OF AIRLIFT RESOURCES

Patrick J. Buckley, Maj, USAF — 168p — GSM/SM/72-2
Bruce C. Walling, Capt, USAF — Lab Sponsor: MAC
Advisor: Maj T. R. Manley

The purpose of this study was to analyze the effects of recent efforts of the Military Airlift Command to improve the planning, scheduling, and operation of strategic airlift resources. The study was based on data collected from Headquarters MAC, Headquarters 21st Air Force, and subordinate units during the summer of 1972. Analysis of interview and questionnaire responses provided statistically significant conclusions concerning the perceived feasibility and acceptability of the new system. The analysis also resulted in worthwhile suggestions for improvements in the new policies and procedures. It was concluded that the new policies, procedures, and management practices had contributed significantly to perceptable and desirable improvements in the stability of resource scheduling.

160. AN ANALYSIS OF OFFICER RETENTION FACTORS WITHIN A TACTICAL AIRLIFT WING (C130E)

Jimmy D. Carver, Maj, USAF — 122p — GSM/SM/72-3
Advisor: Maj T. R. Manley — Lab Sponsor: TAW — AD 754167

This research investigates the retention attitudes of Air Force officers assigned to C-130E equipped Tactical Airlift Wings. This study examines the career attitudes of the younger officer, identifies and ranks in order

various factors inherent in both an Air Force career and an assignment to a Tactical Airlift unit. Additionally, the primary cause for present assignment satisfaction/dissatisfaction is identified. The April 1972 Officer Survye formed the basis of the questionnaire utilized to obtain data. Respondents were asked to identify their career attitudes, assign an importance rating to various retention factors, and to indicate the primary cause for present assignment satisfaction and dissatisfaction. The responses were analyzed using the Chi-Square contingency table. Results of the data analysis indicates Tactical Airlift officers will be retained at a minimum 10% less than the Air Force wide rate. Additionally, the two most important unfavorable factors in an airlift assignment are family separation and little say in future assignments. Conversely, the two most important favorable factors in such an assignment are pay and allowances and the job. Geographical location plays a dual role: it is both the primary cause of assignment satisfaction for one unit while it is also the major cause for dissatisfaction of another unit.

161. A PILOT STUDY OF THE PERSONAL VALUE SYSTEMS OF UNITED STATES AIR FORCE OFFICERS

Stephen B. Dalbey, Capt, USAF — 166p — GSM/SM/72-4
Advisor: Maj T. R. Manley — Lab Sponsor: AFIT — AD 754163

The basic objective of this research was to describe the personal value systems of Air Force officers including a description of value system differences related to various personal and organizational variables. Within the limitations imposed on the research effort, this objective was satisfied. The overall orientation of the officers at Wright-Patterson Air Force Base was an equal mixture of pragmatic and moralethical orientations. Primary orientation was found to be independent of all the personal and organizational variables except Marital Status. Married officers tended to be less mixed and less pragmatically oriented and more moral-ethically oriented than were single officers. The Wright-Patterson Air Force Base officers placed the highest importance on value concepts associated with Goals of Organizations. Value concepts associated with Characteristics of Other People were second in importance. The chi-square contingency table analyses conducted between personal and organizational variable classifications and the behavioral relevance of values revealed 115 significant differences. Primary orientation accounted for the greatest number of differences. The study of personal values of Air Force officers can provide valuable information to Air Force decision makers. Armed with this information, decision makers will be better able to assess the impact of, and response to, Air Force decisions, policies, programs, and goals.

162. A COMPUTER SIMULATION STUDY OF THE ECONOMIC IMPACT OF AUTOMATIC BIN STORAGE AND RETRIEVAL SYSTEMS ON DOD WAREHOUSES

John E. Fiscus, Maj, USAF — 167p — GSM/SM/72-5
Advisor: Lt Col C. J. Doryland — Lab Sponsor: AFSL — AD 754161

A possible means of reducing the level of annual dollar expenditures for storage and warehousing within the Department of Defense is that of reducing the labor manhours required. In this regard, the objective of this research was to evaluate the performance characteristics of

automatic bin storage and retrieval systems (ASRS) and to investigate the potential cost reductions that might accrue from the application of these systems to DOD bin storage facilities. Random number or "Monte Carlo" computer simulation techniques are employed in constructing the model of the ASRS. The effect on transaction rate of variations in carrier velocity, acceleration, positioning at the bin, as well as variations in storage area dimensions are observed and presented in graphical format. An economic analysis model, based on empirically derived labor savings, is used to compute the projected economic impact of an ASRS upon representative DOD depots. The above savings were those which were hypothesized by the research as generated by the introduction of an ASRS into the bin storage activity. The 17 depots selected for analysis represent a cross-section of bin storage activity and responsibility within the DOD. The model evaluates the results of a capital investment in ASRS hardware and installation expenses with respect to net present value, pay-back period and unadjusted rate of return. An analysis of significant findings along with conclusions and recommendations attained as a result of the research are presented as well as topics for future research. The computer programs employed and the underlying logic used in their construction are presented in detail. The results of the program outputs are tabulated in the Appendices along with the raw data used in the analysis of the selected DOD depots.

163. INVESTIGATION OF A PERCEIVED RELATIONSHIP BETWEEN GRADE AND RESPONSIBILITY, AND ITS EFFECT ON CAREER DECISIONS OF YOUNG AIR FORCE OFFICERS

William F. Flanagan, Capt, USAF — 191p — GSM/SM/72-6
Advisor: Lt Col R. P. Yantis — Lab Sponsor: AFSC — AD 754166

This report attempts to answer the following questions, "Do Air Force junior officers perceive the USAF grade system as a hindrance to their obtaining increasing job responsibility commensurate with their capabilities and qualifications?" and "If officers do perceive the grade system as dysfunctional to their obtaining increased responsibility, is this perception causing officers to leave the service?" Following a historical development of military grade, job responsibility is shown to be an important factor in a junior officer's career and in decisions concerning that career. A questionnaire survey was conducted among junior officers in Air Force Systems Command (AFSC), Wright-Patterson Air Force Base (WPAFB), and the 17th Bombardment Wing (SAC), WPAFB, to ascertain what career factors are perceived to be and should be most influential in obtaining increased responsibility. Additionally, the survey's purpose was to discover if officers perceived the USAF grade system as a restrictive factor to their obtaining increased responsibility commensurate with capabilities and qualifications. Officers responding to the survey stated that past performance, experience, education, and training should be the most influential factor in their obtaining increased responsibility. A large proportion of those responding (62.5%) felt that the grade system is a hindrance to obtaining responsibility commensurate with capabilities and qualifications. Furthermore, statistical testing and inferences based on the questionnaire data indicate that this perception of the grade system as dysfunctional to obtaining increasing responsibility is a factor influencing junior officers to possess a negative career intent.

164. THE REARRANGED WORKWEEK OF FOUR DAYS FORTY HOURS WITH A TREATMENT OF MILITARY APPLICATIONS

William J. Foster, Maj, USAF — 120p — GSM/SM/72-7
Advisor: Lt Col R. J. Lucas — Lab Sponsor: MAC — AD 754157

The primary purpose of this study was to develop a military reference on the rearranged workweek, especially the four-day, forty-hour workweek arrangement. In the research, an extensive review of pertinent literature was accomplished to provide the necessary background to properly evaluate the military four-day, forty-hour workweek experience at McGuire Air Force Base, New Jersey. The test program included five percent of the 438th Military Airlift Wing personnel. Civilians were personally excluded from participating in the test program because of Federal overtime laws, although some civil service managers supervised participating military personnel. Interviews were conducted with managerial personnel involved in the limited test program, which lasted from July to November, 1971. The interview questions sought perceptions of relative advantages, disadvantages, problem areas, and level of effectiveness of the test program. Analysis of the responses revelaed a general satisfaction with the 4-40, especially among younger personnel, but a disenchantment with its application in the organization. Most of the managers interviewed forecast a workweek of less than five days as the way of the future. In perceived satisfaction with the program, a significant difference was noted between the top and middle level managers and first-line supervisors. Overwork of the first-line supervisors caused their discontent. The first-line supervisors also expressed goals different from those of the other managers. Whereas the other managers were mainly economic or productivity oriented, the first-line supervisors were people-oriented. A prescriptive model for the evaluation of the program, at different phase points, is included to aid the military manager contemplating such a workweek.

165. JOB AND EQUIPMENT COMPLEXITY: A STUDY OF THEIR IMPACT ON JOB SATISFACTIONS OF AIR FORCE AVIONICS SYSTEMS MAINTENANCE PERSONNEL

Euthemios Hatchion, Maj, USAF — 185p — GSM/SM/72-9
Advisor: Dr. R. H. Klug — Lab Sponsor: TAC — AD 754160

The primary purpose of this study was to determine to what extent the perceived job satisfactions of Air Force avionic systems maintenance technicians were influenced by the perceived complexities of the work role. Data for the research were gathered through personal face-to-face interviews administered to 170 technicians in four Air Force operational units (3 TAC units and 1 SAC unit). Questions asked in the interviews measured individual perceptions of four variables: level of job satisfaction; level of job complexity; level of test and repair equipment complexity; level of system or end-item complexity. The results of the study basically showed that: (1) the level of complexity of the system(s) or end item(s) maintained by the technician had no linear relationship with job satisfaction, (2) the level of complexity of the test and repair equipment used by the technician was positively correlated with job satisfaction, but only to a negligible degree and (3) the level of complexity of the job was positively correlated with job satisfaction, but only to a low degree. It was theorized that in the maintenance environment, the complexity variables may operate as "hygiene" factors in determining job satisfactions.

The results of the open-ened questions showed that: (1) cause for liking the technical aspect of the job was equally divided between those desiring a familiar job and those desiring a job that interested and challenged them and (2) seventy-five percent of the technicians surveyed preferred work allowing repair of individual components (piece-parts) to work involving modular-maintenance (remove and replace) techniques.

166. COMPWARE: A PROPOSED METHOD OF COMPARING DOD DEPOT STORAGE FACILITY PERFORMANCE BASED ON FINANCIAL STATEMENT ANALYSIS

George R. Hennigan, Maj, USAF — 126p — GSM/SM/72-10
Advisor: Lt Col C. J. Doryland — Lab Sponsor: AFSL — AD 754165

This study traces the development of COMPWARE, a proposed method of comparing DOD depot storage facility cost-effectiveness and efficiency, using digital computer techniques. The method herein described is unique because it departs from the cost-benefit analysis traditionally employed in the DOD's non-profit activities. Instead, it uses conventional financial statement analysis concepts. This is done through the assignment of sliding "dummy sales" prices to a facility's output and hence the generation of a "dummy revenue". Magnitudes of these "dummy sales" prices are determined by the priority of the requisition and the promptness with which the order is serviced. Therefore, revenues are a measure of a facility's level of activity and its responsiveness to demand. Costs of goods sold are computed as the facility's annual operating cost including depreciation. A conventional Income Statement is generated and Returns on Investment and Sales are calculated. The study also identifies five Measures of Performance that are not financial. Chief among these are the Inactive FSN Ratio which is a percentage measure of a facility's "dead" stock, the Inventory Turnover which is a measure of the rate at which merchandise is moving through the facility, and a Contribution Quotient that measures contribution to the overall DOD Logistics mission.

167. LONG TERM SERVICE WARRANTY CONTRACTS -- A CASE EXAMPLE OF GYROSCOPES PURCHASED UNDER WARRANTY

Joseph L. Higgins — 127p — GSM/SM/72-11
Advisor: Lt Col R. J. Lucas — Lab Sponsor: AFSC — AD 754158

This study analyzes Air Force organizational and managemental aspects of long term service warranty contract provisions in the procurement of aircraft subsystems. The vehicle for analysis is an Air Force contract which provides for a 3000 hour or 5 year warranty, whichever comes first, for an aircraft gyroscope. Any gyro which fails during the warranty period is repaired or replaced by the contractor under the fixed price of the contract. Two areas are selected for analysis: warranty funding and warranty data requirements. These areas present potential problems which are not encountered in typical procurement and equipment support methods. The analysis shows that there were no contracting difficulties in applying funds to this contract. Multi-year aircraft production funds were used, to include equipment purchase and warranty service. However, other funding schemes are possible. There was conflict between organizational elements of Air Force Systems Command and Air Force Logistics Command in determining who would fund the warranty.

Ultimately, Air Force Systems Command supplied funds for the warranty, although it should be possible for Air Force Logistics Command to do so. Funding or equivalent service adjustments required by the warranty provision involve Air Force Systems Command in traditional logistics functions. Warranty procurement methods have special data requirements to document the warranty life cycle of each item to insure contract compliance. The contract discussed in this study requires additional data to accomplish a contractually specified effectiveness study for the purpose of evaluating warranty concepts in procurement. The analysis shows that data are available from contractor and Air Force data systems to document the warranty life cycle, with one exception. All data required for the warranty effectiveness study are available. Analysis of the data requirements suggests that future comparable procurements must make use of the kinds of data collection and treatment required by this contract in order to take a cost-effective life cycle approach to similar procurements.

168. AN HISTORICAL ANALYSIS OF THE UNITED STATES NAVAL ACADEMY GRADUATES IN THE UNITED STATES AIR FORCE

William E. Hodge, Maj, USAF | 146p | GSM/SM/72-12
Advisor: Lt Col R. J. Lucas | Lab Sponsor: USN | AD 754156

The purpose of this study is to provide an analysis of the Naval Academy graduates who were commissioned in the Air Force upon graduation. Active duty personnel records were searched to determine retention, rank, professional military education, educational level and career field assignments. Comparisons were made between this group and the regular officer complement. A questionnaire was developed to provide biographical data and facts of a personal nature. All graduates, electing the Air Force, from the classes of 1949 through 1960 inclusive, were surveyed. An analysis was made of the respondents in three catagories: active duty, separatees, and retirees. The analysis showed the majority of respondents expressed at least a reasonable degree of certainty of having made the proper choice, by entering the Air Force. Naval Academy graduates appear slightly ahead of their regular officer contemporaries in promotions, and level of professional military education completed. The education level of the Naval Academy graduate is significantly higher than the regular officer complement. There is a highly significant grouping of active duty Naval Academy graduates into the scientific and engineering career fields. The promotional success of the individuals in these career fields is marked. Slightly more than 85% of all active duty graduates reflected satisfaction in their career field progression and assignments. A constant level of job dissatisfaction exists with the active duty personnel, and those separatees in pursuit of careers in the civilian community. The Naval Academy graduate seems to have overcome any obstacle present in pursuing a career other than the one specifically trained for.

169. ANALYSIS OF RESULTS OF OFFICER FY-73 EARLY SEPARATION PROGRAM

Lyle T. Jones, Maj, USAF — 142p — GSM/SM/72-13
Advisor: Lt Col R. P. Yantis — Lab Sponsor: AFSC — AD 754164

A statistical study was made of those officers who applied to separate under the "Officer FY-73 Early Separation Program." The eligible population consisted of non-rated support officers with Total Active Federal Commissioned Service Dates (TAFCSD) of 1 July 1961 through 31 December 1970. Computer printouts from a mechanized UOR File were made on both the applicants and the eligibles. The officers were placed into Fiscal Year groups based on TAFCSD and classified according to characteristics of Component, Race, Source of Commission, Education Level, Functional Area of Duty Assignment, Major Air Command of Assignment, and Active Duty Service Commitment remaining to be fulfilled. Difference of Proportions and Chi-square tests, at the .05 level of significance, were used to determine which classifications of officers had higher or lower application rates that would indicate any areas of concern for Air Force officer personnel managers. Some of the results found for the total program were: service academy graduates had a higher application rate than the other sources of commission; officers with a graduate degree applied to separate at a higher rate than those with less education; those officers with an OER mean of 9.0 had the highest application rate in that classification; the operational flying commands had higher application rates than the other major air commands. It is recommended that continuing studies of this nature be accomplished on all officer voluntary separation programs.

170. AN AFLC MANPOWER REQUIREMENTS MODEL FOR THE MATERIEL MANAGEMENT OF CONSUMABLE ITEMS

Raymond A. Seaman, Maj, USAF — 125p — GSM/SM/72-17
Advisor: Prof J. P. Cain — Lab Sponsor: AFLC

This study develops a model which enables AFLC to separate and identify the manpower resources necessary for the materiel management of Air Force consumable items. It can be used to easily compute the appropriate number of manpower slots to be released when a specified quantity of EOQ items is transferred to DSA for Integrated Materiel Management. The concept and history of Integrated Materiel Management are first reviewed and summarized. Then, the methodology and analytical tools used to develop the model are explained. The procedure is to logically select various workload factors which influence or relate to materiel management manpower needs. Next, stepwise linear regression is used to select the optimum combination of these workload variables which best explains the relation. Two possible models are produced; one is bivariate and one multivariate. After careful comparison and evaluation of the features and limitations of each, the multivariate model is selected as the best forecasting model. This decision is based primarily on the accuracy of the model predictions. The model estimates Total Actual Materiel Management Manhours as a function of the variables, Total EOQ Items Managed and Total Aircraft Flying Hours. Thus, it enables the delineation of that part of total manhours which is attributable to the number of EOQ items managed.

171. SURVEY AND ANALYSIS OF THE DESIRES AND OPINIONS OF PROSPECTIVE CANDIDATES FOR ADVANCED EDUCATION THROUGH AFIT'S MASTER'S DEGREE PROGRAM

Jeffrey D. Silliman, Capt, USAF — 190p — GSM/SM/72-18
Advisor: Dr. R. H. Klug — Lab Sponsor: AFIT

The report provides a description of the attitudes and opinions of potential candidates toward advanced education and toward the three Air Force Institute of Technology (AFIT) Master's degree programs: the Residence School of Engineering, the School of Systems and Logistics, and the Civilian Institutions Program. Particular attention is given to the Residence School of Engineering. It also investigates the relationships that exist between the backgrounds of the potential candidates and their evaluation of advanced academic education and the AFIT programs. The report seeks to identify and evaluate those factors within the AFIT Master's programs that are most detrimental to the selection and acceptance of these programs by the potential candidates. The report methodology consisted of a survey administered to a sample of Air Force officers representing potential candidates for the AFIT Master's programs considered in this study. This survey consisted of variables concerning background, attitudes toward advanced education, and attitudes toward AFIT programs. These variables were scored and correlated using programs from the Biomedical Computer Program group. Those correlations found were further examined using contingency tables provided by multiple sorts and scoring of the respective variables. Analysis of the survey variables and the relationships existing among these variables indicated the following major findings: (1) The attitudes and opinions of potential candidates are directly related to the candidates' view of education as a requirement for career success. (2) There does not exist a large body of gross misconceptions among potential candidates regarding the AFIT residence programs. (3) The three-for-one service commitment policy of AFIT is not a serious deterrent to the acceptance by potential candidates of the AFIT programs. (4) The prestige of the AFIT residence programs is considered by the potential candidates to be above average but not equal to "name" graduate institutions. (5) The most detrimental factors to the acceptance of AFIT residence programs are the lack of breadth and lack of flexibility of the curriculum within the residence programs. (6) Management is viewed by the potential candidates as being the most advantageous and usable area for application in a military career. Management is the single most desired area of graduate study for the Air Force officer.

172. A STUDY OF THE APPLICABILITY OF REGRESSION METHODS TO JOB SATISFACTION ANALYSIS

Dennis A. Smith, Capt, USAF — 191p — GSM/SM/72-19
Advisor: Prof J. P. Cain — Lab Sponsor: ASD — AD 754159

This research concerns the measurement of attitudes regarding job satisfaction and the isolation of factors influencing the variation in the levels of satisfaction. It also evaluates the effectiveness of the linear regression method as a means of statistical analysis for the determination of those variables that have an effect on explaining the variation in job satisfaction. The measurement of the job satisfaction parameters consists of measuring employee perceptions of five

key factors in their jobs. These factors are achievement, job interest, recognition, advancement, and responsibility. Perceptions of security on the job, the relative importance of the motivators, and ratings of other factors relating to job satisfaction were also measured. The research sample was taken from the Deputy for Systems, Aeronautical Systems Division, Wright-Patterson AFB, Ohio. Sixty-eight military and 136 civilian personnel in all grades responded. The major finding of this research with respect to the regression methodology is that it is very effective in isolating and identifying those factors which are statistically important to the explanation of the variation in the dependent variables analyzed. The findings provided by the regression analysis are quite lengthy. The most important are as follows: (1) The military employees have a higher level of job involvement and job satisfaction than the civilian employees. (2) The contribution of the job to status in the organization is directly related to the level of job satisfaction and perceptions of satisfaction of the motivators. (3) Participation in decision-making has a positive effect on many of the motivators for both civilian and military employees. (4) A higher perception of satisfaction is realized by those employees who feel that their abilities are considered for promotion and the assignment of work to them. (5) The civilian employees respond to a supervisor with a democratic power style, while the military employees are positively effected by a supervisor with a high orientation toward the task or mission.

173. STORAGE SPACE REQUIREMENTS PLANNING FOR DEFENSE DEPOTS

Clarence E. Strebel, Lt Col, USAF — 113p — GSM/SM/72-21
Advisor: Lt Col C. J. Doryland — Lab Sponsor: AFSL — AD 754162

This report is the result of an examination of the factors effecting warehouse space requirements planning for the DOD. The prime objective of the study was specification of planning factors which are related to pre-programmed force size and activity, and which could be used for the prediction of warehouse space. A closely related objective was the examination of the probable effect of hardware, mission, and policy changes upon the validity of the specified factors for storage space prediction. Multiple linear regression analysis was applied to Air Force oriented force size and activity data, but the methodology, findings and conclusions have applications to other DOD components. A technically sound regression was obtained, although it was concluded that the 43% standard deviation was excessive for forecast purposes. It was also shown that large differences between reported and utilized space can result due to the reporting of square feet instead of cubic feet. Major report recommendations are the implementation of mechanized cubic feet reporting of storage space, industrial funding of the storage function, and the development of a space forecast model based on explicit policy alternatives, funding constraints, and historically based system dynamics.

PART III

ABSTRACTS OF DOCTORAL DISSERTATIONS

174. COMPUTATIONAL ALGORITHM FOR UNCONSTRAINED MINIMIZATION

Bruce T. Kujawski, Capt, USAF — 60p — DS/EE/72-1
Advisor: Lt Col R. A. Hannen — Lab Sponsor: AFFDL — AD 747277

A generalized descent algorithm theory is developed for unconstrained minimization problems. Here a descent algorithm is defined as a computational procedure where at each iteration a descent direction is determined and a single dimensional search is made for the minimum in the descent direction. The theory is shown to be a generalization of the three most common descent algorithms; gradient, conjugate gradient and Fletcher-Powell. Since execution of the single dimensional search can be computationally time consuming, two additional algorithms are presented which reduce or eliminate single dimensional search time. The first is a modification of Davidon's Variance Algorithm and requires a minimal single dimensional search. The second is a direct method for minimizing a special class of quadratic functions.

175. TRUNCATED POWER SERIES CONTROL REPRESENTATIONS FOR OPTIMIZATION OF DYNAMIC SYSTEMS

Austin L. Foote, Maj, USAF — 151p — DS/EE/72-2
Advisor: Capt D. H. deDoes — Lab Sponsor: AFAL — AD 748312

The set of candidate controls for the solution of an optimal control problem is defined as a finite set of constant coefficient truncated power series. The variables present in the truncated power series are limited to the state variables in the system and the independent variable time. The control solution may thus be limited to a form which can be simply and inexpensively implemented into a system. Multistage optimal control problems with both equality and inequality boundary conditions are considered. A set of necessary conditions and a set of sufficient conditions for a relative minimum solution are developed for an optimal control problem with equality constraints. Solutions to the equations comprising these necessary conditions can be obtained using recursive algorithms. A method called the vector cost method is developed to obtain quasi-optimal solutions to optimal control problems with inequality constraints. In this method, a composite optimal control problem with equality constraints is defined whose solution is a quasi-optimal solution to the original problem. Five examples of optimal control problems with equality constraints and four examples with inequality constraints are solved to demonstrate the application of truncated power series controllers to dynamic systems.

176. ANALYSIS AND EXTENSION OF LUMPED PARAMETER NONLINEAR ESTIMATION ALGORITHMS

Stephen R. Schwam, Capt, USAF — 218p — DS/EE/72-3
Advisor: Dr. G. B. Lamont — Lab Sponsor: AFAL — AD 747282

The system considered in this investigation is assumed to be modeled by a continuous nonlinear stochastic differential equation observed at discrete intervals by a nonlinear observation equation with

additive noise. Because of the restrictions placed upon the stochastic differential equation, the Ito and Stratonovich interpretations are equivalent and the rules of ordinary calculus are used. Two second order filters (with second order truncation of Taylor series nonlinear function representation and second central moment truncation of probability density function representation) are presented. Their truncation and roundoff errors are analyzed. A perturbation form of second order filter is derived in order to reduce algorithm sensitivity to roundoff errors. A power series perturbation analysis about an arbitrary unspecified nominal trajectory is used to derive a new second order perturbation filter which is capable of accepting various deterministic nominal trajectories between discrete observations. A local error susceptibility analysis of the conditional moment evolution equations for both previously suggested and originally developed filters is presented. This analysis is proposed for use as an estimation algorithm selection criterion. The new second order perturbation filter and the roundoff, truncation, and error susceptibility analyses are applied to a multidimensional, nonlinear example problem with real data. A previously proposed fixed interval, maximum likelihood smoother which will converge for second order dynamic and measurement non-linearities is presented, modified, and then improved with the addition of a sample path dependent iteration procedure. Flowcharts and descriptions of the computer mechanizations used to solve many of the example problems are provided.

177. ANALYSIS OF THE DYNAMICS OF ELASTIC STRUCTURES BY THE FINITE ELEMENT METHOD

Richard J. Talbot, Maj, USAF — 163p — DS/MC/72-1
Advisor: Dr. J. S. Przemieniecki — Lab Sponsor: AFFDL — AD 747283

The finite element displacement method has been used to investigate the transient response and dispersive behavior of elastic structures. An improved technique for integrating the finite element equation of motion has also been developed. The stability characteristics of the algorithm have been determined and charts prepared which permit rapid determination of the critical time step length. The artificial phase shift and attenuation caused by the algorithm have also been determined. It is demonstrated that these undesirable effects can be minimized by including sufficient terms in the time expansion which is used to derive the algorithm. The finite element displacement method has been used to study the dispersive characteristics of elastic waveguides. Several new finite elements, which include the wavenumber of the stress wave as a parameter, have been formulated. These elements have been used to obtain dispersion curves for the circular rod, the square bar, and an equilateral triangle waveguide. In the case of the circular rod waveguide, it has been demonstrated that the finite element formulation can be used to obtain longitudinal mode spectra which are in excellent agreement with the exact solution over an extended range of frequency and wavenumber. The rate at which the finite element results converge to the exact solution as a function of the number and distribution of elements used to model the waveguide cross section has also been investigated. This information is then used to assess the accuracy of the spectra for the other waveguide analyses, since no exact solutions are available for these cases. The versatility of the method

has been illustrated by obtaining the longitudinal mode spectrum for a unidirectional fiber reinforced composite. The results are compared to two prior theoretical investigations and are shown to be in better agreement with experimental data than either of the earlier analyses. The new finite time step algorithm was used to study the response of a finite length fixed-free circular rod to a step pressure applied at the free end. The longitudinal displacement response is shown to be in good agreement with the one-dimensional solution and that the transient displacement response predictions near the free end are comparable with prior finite difference analyses.

PART IV

ABSTRACTS OF FACULTY PUBLICATIONS

178. A REAL-TIME CLOSED-LOOP SOLUTION METHOD FOR A CLASS OF NONLINEAR DIFFERENTIAL GAMES

Gerald M. Anderson, Major, USAF 3p Lab Sponsor: AFFDL

Institute of Electrical and Electronic Engineers Transactions on Automatic Control, AC-17:4:576-577, August 1972

This correspondence presents a method for generating near-optimal closed-loop solutions to fixed time differential games with unconstrained controls by periodically updating the solution to the two-point boundary-value problem obtained by the application of the necessary condition for a saddle-point solution. This method should permit the real-time closed-loop solution of this class of games using a digital or hybrid computer.

179. AN INDIRECT NUMERICAL METHOD FOR THE SOLUTION OF A CLASS OF OPTIMAL CONTROL PROBLEMS WITH SINGULAR ARCS

Gerald M. Anderson, Major, USAF 3p Lab Sponsor: AFFDL

Institute of Electrical and Electronic Engineers Transactions on Automatic Control, AC-17:3:363-365, June 1972

An indirect numerical method is presented that solves a class of optimal control problems that have a singular arc occurring after an initial nonsingular arc. This method iterates on the subset of initial costate variables that enforce the junction conditions for switching to a singular arc, and the time of switching off of the singular arc to a final nonsingular arc, to reduce a terminal error function of the final conditions to zero. This results in the solution to the two-point boundary-value problem obtained using the minimum principle and some necessary conditions for singular arcs. The main advantage of this method is that the exact solution to the two-point boundary-value problem is obtained. The main disadvantage is that the sequence of controls for the problem must be known to apply this method. Two illustrative examples are presented.

180. A STUDY OF THE PROPULSION PERFORMANCE FROM PLASTICIZED EXPLOSIVES

Robert R. Bestgen, Capt, USAF 45p Lab Sponsor: AFRPL
J. R. Nunn, Capt, USAF

Air Force Rocket Propulsion Laboratory Technical Report (AFRPL-TR) 72-56, (October 71 - May 72) August 1972

A theoretical study was made to determine the performance of a detonation propulsion system using plasticized explosives. Steady-state and shock-hydrodynamic calculations were completed for: (1) free-expansion detonations, where the explosive gases are free to expand from the vehicle mass after impacting the vehicle, (2) confined detonations, where recoil mass or attenuator mass is used to constrain the expansion, and (3) totally confined detonations, where the momentum transfer to the vehicle mass and the conversion of detonation energy into vehicle kinetic energy are maximized. The effects upon propulsion performance of separating explosive charges from the vehicle mass, giving the explosive charge an initial velocity, and stacking explosive charges between solid materials, were also studied. Results show that a free-expansion detonation delivers a specific impulse comparable to that of a conventional chemical rocket using solid propellant. Separating the explosive charge from the vehicle can result in a moderate increase in the performance

of a detonation propulsion system. Giving the explosive an initial velocity also increases performance, although this may be of marginal practical utility. Partially confining a detonation with material increases the momentum transfer to the vehicle and the vehicle's kinetic energy, but the confinement is not comparable to adding an equivalent amount of explosive mass. Stacking explosives between materisls leads to a similar result. A totally confined detonation delivers the maximum performance from a detonation propulsion system, but vehicle damage is likely when using a totally confined detonation. The results indicate that the detonation propulsion concept is feasible for special purpose applications where the specific impulse required is about 250 to 300 seconds.

181. FEW GROUP S_n THERMAL X-RAY TRANSPORT WITH ANISOTROPIC COMPTON SCATTER

Charles J. Bridgman — Lab Sponsor: AFWL
Brian G. Stephan, Capt, USAF

American Nuclear Society 1972 Annual Meeting, Transactions, Vol 15, #1, 18-22 June 1972

This paper reports a systematic investigation of a thermal X-ray discrete ordinates benchmark problem in which the isotropy of the scattering kernel was as high as p_3 and the number of groups as few as 10. This problem involved the steady-state transmission of a distributed source of X-rays through a thin slab of free electrons. The transport was calculated by discrete S_n. The source and target electron temperatures, the angular behavior of the source, the number of energy groups, the degree of angular quadrature, and the degree of kernel expansion were all parametrically varied. Thermal X-ray energies between 0.05 and 400 keV and electron temperatures between 0.5 and 20 keV were studied. The results from 40-energy group S_{16} and p_3 kernel expansion were chosen as the benchmark. Ten sets of 134-group cross sections were computed for the temperatures above using relativistic Maxwellian electron and Wein photon distributions. These data were then collapsed to 10, 20, and 40 groups. Results with source and electron temperatures equal showed that the kernel is adequately represented by a two-term Legendre expansion. In optically thin regions, an S_8 angular quadrature is sufficient for near-isotropic sources, while S_{16} or larger quadratures are necessary for highly anisotropic sources.

182. ANODIC POLARIZATION BEHAVIOR OF Fe-Si ALLOYS IN SULFURIC ACID SOLUTIONS

Wesley B. Crow, Capt, USAF — 6p — Lab Sponsor: AFML
James R. Myers, J. V. Jeffreys

Corrosion, Vol 28, No. 3, pp 77-82, March 1972

Anodic polarization behavior of annealed, high purity Fe and five binary Fe-Si alloys in hydrogen saturated, 1, 5, and 10N sulfuric acid solutions was investigated at 22 ±1 C (72 F) using a potentiostatic technique. All specimens exhibited active, passive, and transpassive behavior in all acid environments. Additions of 12 and 15 wt % Si eliminated the critical current density plateau, significantly decreased the value of critical current density, and increased the width of the passive region. Corrosion potentials, E_{corr}, for pure Fe and the Fe-Si alloys were linear functions of pH over the pH range -1.07 to +1.09.

Slope dependency of the corrosion potential with pH (dE_{corr}/dpH) varied from -0.046 to -0.068, independent of composition. Critical potentials, E_{cr}, for the 88Fe-12Si and 85Fe-15Si alloys shifted linearly in the noble potential direction with decreasing pH; slope dependency (dE_{cr}/dpH) for these alloys was -0.053 and -0.066, respectively. As the Si content was increased from 0 to 9 wt %, the passive current density, i_p, increased. Maximum i_p occurred with the addition of 6 wt % Si. Addition of 12 wt % Si markedly decreased the value of i_p. All specimens exhibited transpassive Tafel behavior. Visible oxygen evolution was not observed for the 88Fe-12Si and 85Fe-15Si alloys.

183. EFFECTIVE TECHNICAL COMMUNICATIONS, EXPRESSION - EXPERIMENT II

Richard M. Davis 90p Lab Sponsor: AFIT

Air Force Institute of Technology Technical Report (AFIT-TR) 72-3, April 1972

The effects of four variables in the expression of a written technical message upon the effectiveness of the message were tested on four definably different audiences in a 2 x 2 x 2 x 2 factorial experiment. The message was a 2342-word passage describing a simple mechanical device and containing ten line drawings. The variables tested were sentence length, agreement in number between subject and verb, shifts in point-of-view, and spelling. The effectiveness of the message was measured by a comprehension test, reading time, judgments of the author's knowledge of his subject, and judgments of the author's competence as a writer. The four audiences tested were drawn from the student bodies at the University of New South Wales, the Southern Alberta Institute of Technology, the Air Force Academy, and AFIT-School of Engineering. Audience contrasts were made on the basis of sex, intelligence, technical inclination, and the country in which the subjects lived (variety of English spoken). Three effects significant at the .01 level of probability and nine significant at the .05 level of probability were found. Each variable tested and each measure of the effectiveness of the message was involved in one or more of the significant effects. Generally, they indicated that the variant forms of the variables impaired the effectiveness of the message. Contrasts of total comprehension by individual audiences support the hypotheses that more intelligent groups understand the material better than do those at a lower level of intelligence and, that at a given level of intelligence, subjects with known technical inclinations understand the material better than do those without known technical inclinations.

184. FLIGHT OF THE ARCHAEOPTERYX

Richard M. Davis 2p

Technical Communications, Vol. 19, No. 4, pp 12-13, December 1972

A research proposal for the development of a new weapons system (a wheel) is submitted by the Department of Aggressive Deterrence for evaluation by the Archaeopteryx Wing of the Rocks, Clubs, and Snares Division. With the exemplary tact typical of all of its actions, the Archaeopteryx Wing rejects the proposal and suggests possible alternative research projects. But because (1) the projected system may have some potential, and (2) its publication might in some way reflect the success of intelligence efforts, permission to publish the proposal is denied.

185. SLOPPY TYPING AND REPRODUCTION IN A WRITTEN TECHNICAL MESSAGE - AN EXPERIMENT

Richard M. Davis 13p Lab Sponsor: AFIT

Journal of Technical Writing and Communication, Vol 2, No. 1, pp 43-55, January 1972

An experiment was performed to determine the effect (if any) of sloppy typing and reproduction upon the effectiveness of a written technical message. The variables tested were margins, the way in which corrections were made, and the reproduction of the message. Approximately seven hundred subjects in five definably different audiences were tested. Measures were taken of comprehension, reading time, judgment of the author's competence as a writer, and judgment of the author's credibility. Five main effects and five interactions were found at the 0.05 level of probability. Each variable, each measure of the effectiveness of the message, and each audience was involved in one or more of these effects. In each main effect and each interaction subject to easy interpretation, the unaltered from (good typing and good reproduction) of the variable(s) concerned appeared to be the more effective.

186. A STUDY OF THE PRACTICALITY OF ACTIVE VIBRATION ISOLATION APPLIED TO AIRCRAFT DURING THE TAXI CONDITIONS

James D. Dillow, Maj, USAF 168p Lab Sponsor: AFFDL
Charles D. Corsetti, 1/Lt, USAF

Air Force Flight Dynamics Laboratory Technical Report (AFFDL-TR) 71-159, July 1972

The feasibility of using an active control in the landing gear system of an aircraft to reduce wing fatigue damage resulting from ground induced vibrations during taxiing is considered. The characteristics of three vehicle models are discussed: a single landing gear system, a tricycle landing gear system and a system of five landing gears. Mathematical expressions for the runway inputs to each vehicle model are obtained in the form of random inputs represented by Gauss-Markov processes. The model for a linear hydraulic actuator which is used as the active control element in the landing gear system is presented. The approach used in the study is to determine an optimal control law which is a proportional feedback of the measurements. The measurements, in turn, are assumed to be both a linear transformation of the states and noiseless. The feedback gains in the optimal control law are obtained in such a way as to minimize a cost criterion which is a measure of the controller's ability to reduce wing fatigue resulting from runway imposed vibrations. The methodology for obtaining the optimal solution for the given cost criterion is developed and solutions for the three different models and for various measurement schemes are obtained. The results indicate that the combined optimal active control and landing gear system can provide a substantial improvement in reducing wing fatigue over that of the landing gear alone. Also, the control parameters that are necessary and desirable in the optimal system, together with the physical demands placed on the actuator, are determined.

187. THE EFFECT OF HIGHER ALKANES ON THE IGNITION OF METHANE-OXYGEN-ARGON MIXTURES IN SHOCK WAVES

Ernest A. Dorko 6p Lab Sponsor: ARL
Robert W. Crossley, Maj, USAF, Karl Scheller, Alexander Burcat

Combustion and Flame, 19, pp 373-378, 1972

Ignition delay times and product distribution were observed in mixtures of methane-oxygen-argon to which different amounts of ethane, propane, butane and pentane were added. All produced appreciable reduction in ignition delay time, which at low additive concentrations could be correlated in terms of the thermal effects. However, chemical analysis of quenched reacting mixtures and kinetic model calculations indicated that the additive influence was chemical and not thermal. An explanation is advanced for the thermal correlation and its breakdown.

188. SOLID STATE REACTION KINETICS III. THE CALCULATION OF RATE CONSTANTS OF DECOMPOSITION FOR A MELTING SYSTEM UNDERGOING VOLUME AND SURFACE CHANGES

Ernest A. Dorko 4p Lab Sponsor: ARL
Robert W. Crossley, Maj, USAF

Journal of Physical Chemistry, 76, pp 2253-2257, 1972

A new physical and mathematical model for autocatalytic decomposition of a solid which undergoes melting is described. The object of the new model is to allow the entire reaction to be described by one set of kinetic parameters. The model includes a time variant parameter, μ, which incorporates spatial distribution of reactants and products in the sensible region, reaction surface distribution, and phase, as well as total material loss. The mathematical manipulations and numerical operations performed to obtain values of μ and the kinetic parameters are presented. A computer program employing a grid search technique to determine Arrhenius activation parameters over short temperature ranges was also developed for use with the decomposition data. From the results of this program it is possible to distinguish regions of the reaction which are controlled by a single mechanism from those which are influenced significantly by competing mechanisms.

189. PROCESS FOR THE DEUTERATION OF THE HYDROXYL POSITION OF ORGANIC ALCOHOLS

Ernest A. Dorko 4p Lab Sponsor: USAMC

United States Patent Office, Patent No. 3,657,363, 18 April 1972

A novel process for the preparation of organic alcohols in which the hydroxyl position contains a deuterium atom. The process involves adding a quantity of the alkali metal salt of an organic alcohol (i.e., t-butyl alcohol) in small portions to a three-fold molar amount of deuterium oxide. The reaction mixture is stirred vigorously during the addition. The resulting mixture of deuterated alcohol, potassium deuteroxide and deuterium oxide (heavy water) is distilled. The appropriate alcohol fraction is separated in the distillation process and final traces of heavy water and water from the atmosphere are removed by passage of the fraction through barium oxide. The process represents a great simplification of the previous process.

190. A BOUNDARY VALUE PROBLEM

Clarence R. Edstrom 2p Lab Sponsor: ARL

Mathematics Magazine, Vol. 45, No. 3, pp 149-150, May-June 1972

This paper presents a solution of the one-dimensional wave equation subject to a time dependent boundary condition. There is given a change of dependent variable which transforms the boundary value problem so that the method of separation of variables can be applied and the solution is obtained.

191. A DIRICHLET PROBLEM

Clarence R. Edstrom 2p Lab Sponsor: ARL

Mathematics Magazine, Vol. 45, No. 4, pp 204-205, September-October 1972

This paper presents the sum of a series of variable terms by solving two related Dirichlet problems and comparing their solutions.

192. A SOLUTION OF LAPLACE'S EQUATION FOR A SEMI-INFINITE STRIP

Clarence R. Edstrom 6p Lab Sponsor: ARL

Mathematics Magazine, Vol. 45, No. 5, pp 254-259, November-December 1972

This paper presents a solution of Laplace's equation for a semi-infinite strip with a prescribed function on one of the infinite edges. A method is given for finding a change of dependent variable which transforms the boundary value problem so that the method of separation of variables can be applied and the solution is obtained.

193. BULK ELECTRICAL PROPERTIES OF CHLOROCARBONS

Robert E. Fontana 2p Lab Sponsor: ARL
Leonard Spialter, Anthony Martinez III, Elwood Wysong

Extended Abstracts, V72-1, pp 16-17, Electrochemical Society, Inc., Princeton, New Jersey, May 1972

A new class of alkaromatic chlorocarbons, molecules containing principally and, in some cases, exclusively, only chlorine and carbon atoms has recently been developed. Many of such compounds have been found to exhibit extreme chemical inertness (resisting boiling nitric acid for more than 200 hours) and thermal stability (above 500°C). In addition, synthetic procedures have been found to prepare polymers, free radicals and both carbon-centered anions and cations, all suprisingly stable, within this class. This report represents the first measurements of the basic parameters of polarization, dielectric constant and volume conductivity of such substances in order to indicate their potential utility in electrical and electronic applications and provide a reference for correlating changes in such properties with changes in molecular structure. Analysis of the data and study of the reported physical properties of the known chlorocarbons suggest ready candidate materials for high temperature transformer fluids and insulating composites.

194. EFFECTIVE DIMENSIONAL REDUCTION IN THE COMPUTATION OF LINEAR, DISCRETE, TIME-DELAY PROBLEMS

Jerry L. Hanson, Lt Col, USAF 11p Lab Sponsor: RADC

Proceedings, 10th Annual Institute of Electrical & Electronic Engineers Region 3 Convention, pp B5-1 - B5-2, IEEE, New York, N. Y., April 1972

Probably the most direct method of handling linear, discrete problems with time delays is by using an enlarged state vector to eliminate the delays. The main disadvantage of this technique is the increased dimensions of the resulting matrices. This paper shows, through an illustrative example, that these dimensions (and thus the storage requirements and computational time) can be effectively reduced. Thus the method is computationally feasible for a larger class of problems than if standard matrix algebra routines were used.

195. UV PHOTOEMISSION MEASUREMENTS OF THE UPPER D-LEVELS IN THE IIB-VIA COMPOUNDS

Robert L. Hengehold 6p Lab Sponsor: ARL
Charles J. Vesely, Maj, USAF, Dietrich W. Langer

Physical Review,B, 5, pp 2296-2301, March 1972

Photoemission measurements have been made of the upper d levels in ZnO, ZnSe, ZnTe, CdS, CdSe, CdTe, HgSe, and HgTe using 21.2-eV (584-Å) and 16.8-eV (740-Å) radiation. All the samples except for HgSe and HgTe were cleaved and measured in an oil-free ion-pumped vacuum system at a pressure in the 10^{-7}-10^{-8} Torr range. The results agree extremely well with values obtained by X-ray-induced-electron-emission spectroscopy. The spectra obtained for HgSe and HgTe make it possible to positively verify the identification of certain peaks observed in photoemission spectra of the IIB-VIA compounds as being due to the upper d levels. The photoemission results reported in this study are also compared with both reflectivity and energy loss measurements to obtain information about the optical density of states in the conduction bands of these compounds.

196. A COMPARISON OF X-RAY AND UV INDUCED ELECTRON EMISSION STUDIES OF THE UPPER D-LEVELS IN THE IIB-VIA COMPOUNDS

Robert L. Hengehold 5p Lab Sponsor: ARL
Charles J. Vesely, Maj, USAF, Dietrich W. Langer

Electron Spectroscopy, North-Holland Publishing Company, pp 535-539, Amsterdam, Holland, January 1972

UV induced electron emission measurements have been made of the upper d-levels in several of the IIB-VIA compounds using 16.8 and 21.2 eV radiation. The results are compared with values previously obtained by X-ray induced electron spectroscopy. The purpose of this study was to investigate the validity of a method used for determining the amount of charge buildup on the surface of high-resistivity samples and, for semiconductors, the validity of an assumption concerning the effective location of the Fermi level while an X-ray measurement is in progress. The conclusion is that X-ray electron spectroscopy can indeed be used to study the core electron levels in semiconductors with a high degree of precision.

197. ELECTRON ENERGY-LOSS SPECTRA OF ZnS, ZnSe, AND ZnTe

Robert L. Hengehold 6p Lab Sponsor: ARL
Frank L. Pedrotti

Physical Review B, 6, pp 3026-3031, October 1972

A study has been made of the electron energy-loss spectra of the three IIB-VIA compounds ZnS, ZnSe, and ZnTe. These spectra have been obtained both by electron-reflection and electron-transmission techniques. The electron-reflection measurements were made from freshly cleaved single-crystal surfaces of all three compunds in an ultrahigh-vacuum atmosphere. Changes in these spectra were observed as the surface was slowly contaminated. The electron-transmission measurements were made only on ZnTe using flash-evaporated thin films. The quality of these films was established by means of X-ray-diffraction, optical-reflectivity, and optical-absorption measurements. The peaks observed in these spectra have been interpreted in terms of interband transitions, surface plasmons, and bulk plasmons. The results are compared with optical-reflectivity measurements and X-ray-induced electron-emission measurements.

198. ELECTRON ENERGY LOSS SPECTRA OF CdS, CdSe AND CdTe

Robert L. Hengehold 7p Lab Sponsor: ARL
Frank L. Pedrotti

Physical Review B, 6, pp 2262-2268, September 1972

A study has been made of the electron energy-loss spectra of the three IIB-VIA compounds, CdS, CdSe, and CdTe. These spectra have been obtained by both electron reflection and electron transmission. The electron-reflection measurements were made over an energy-loss range of 0 to 50 eV on single crystals cleaved in an ultrahigh vacuum atmosphere. Changes in these spectra were then observed as the surface was slowly contaminated. The electron-transmission measurements were made using as-grown platelets or thin films. The spectra of these compounds consist of a series of low-lying peaks between 0 and 9 eV associated with interband transitions from the valence band and a peak between 12 and 15 eV associated with an interband transition from the d band. There also exists a peak between 9 and 12 eV and another between 15 and 19 eV. The former has been tentatively identified as a surface-plasmon peak, the latter as a bulk plasmon. These results are compared with optical reflectivity measurements and induced-electron-emission measurements.

199. NONEQUILIBRIUM COMBUSTION EFFECTS IN SUPERSONIC STREAMS

Renaldo M. Jensen, Maj, USAF 45p Lab Sponsor: NASA
C. A. Bryce, B. A. Reese

National Aeronautics and Space Administration Scientific Technical Aerospace Reports, NASA CR No. 120932, May 1972

Theoretical and experimental studies have demonstrated the potential for aircraft capable of operating at hypersonic speeds within the atmosphere with an air breathing engine employing supersonic combustion. Duplication of true flight conditions in ground testing these propulsive systems

requires a significant extension of existing facility capabilities and operating ranges. However, the nature of the flow at these extreme conditions does not completely simulate the actual flight conditions experienced by the Supersonic Combustion Ramjet (SCRAMJET) engine because the flowing gas stream is not in complete thermal and chemical equilibrium. This research program is a theoretical and experimental investigation of the effect of nonequilibrium conditions upon the performance of combustors employing supersonic flows. Calculations and experiments were made regarding the effects on the ignition of hydrogen of the nonequilibrium species (free radicals, atoms, water vapor, etc.) obtained using vitiated air. Results of this investigation show that the nonequilibrium free-radical content from a supersonic vitiated air source will cause early ignition of the hydrogen. An analysis of heated air expended from a high temperature source to test section conditions also indicates that there is sufficient free radical content in the incoming flow to cause early ignition. Water vapor, an inherent contaminent in the generation of vitiated air, was found to reduce the ignition delay period under the experimental conditions considered.

200. FLOW OF GASES IN GRANULAR MEDIA AT LOW PRESSURES

Stewart W. Johnson, Lt Col, USAF Lab Sponsor: AFIT
R. Torrence Martin, W. David Carrier, III, Jerome L. Winkler

Transactions, American Geophysical Union, 53:4:440, April 1972

With the goal of determining the permeability of granular media to gases in the molecular flow regime, an apparatus has been designed and placed into operation which accepts samples 5.7 cm in diameter and 1 to 10 cm thick. Samples used have been of two types, a uniform silica sand and a comminuted basalt with grain size distribution matching that found at the Apollo 12 landing site. In tests the system is initially pumped down to the 10^{-7} to 10^{-9} torr range and then a small quantity of a known gas, helium, nitrogen, argon, or krypton, is introduced into the system on the upstream side of the sample. Upstream and downstream pressures are continuously monitored and controlled. At the steady-flow condition, with an upstream pressure of 10^{-4} to 10^{-6} torr, rates of flow into and out of the sample are determined and partial pressures of gases on the downstream side of the sample are measured with a residual gas analyzer. Results show sample conductance for the uniform sand 1 cm thick obtained are useful in making inferences as to the present state of outgassing of the lunar regolith given various gas sources, such as water vapor or permafrost, at depth and considering the nature of the lunar atmosphere.

201. THE LUNAR REGOLITH AS A SITE FOR AN ASTRONOMICAL OBSERVATORY

Stewart W. Johnson, Lt Col, USAF 18p Lab Sponsor: NASA
K. J. Rohloff, 1/Lt, USAF, J. N. Whitmire, Capt, USAF, A. P. Pyrz, Capt, USAF,
G. W. Ullrich, 1/Lt, USAF, D. G. Lee, Capt, USAF

Proceedings, Ninth International Symposium on Space Technology & Science, pp 1059-1076, AGNE Publishing Inc., Tokyo, Japan, 1972

Results of lunar studies show the regolith to consist of a fragmental layer resulting from a complex interaction of depositional processes involving meteoroid impact, volcanism, and mass wasting. The unique lunar environment,

with its extremely tenuous atmosphere, its weak gravitational field, and its regolith of variable thickness, offers both advantages and disadvantages as a site for an astronomical observatory. We assumed that a large optical telescope, which was discussed in detail by North American Aviation in a 1966 report to NASA, could be established on the Moon in 1985-1990 and used existing knowledge of properties of the lunar regolith to evaluate several observatory foundation concepts. The cases of a shallow regolith and a deep regolith were evaluated for two observatory configurations; one configuration in which a rotatable collecting mirror is vertically above a fixed focusing mirror and the other in which these two mirrors are in horizontal alignment. The concept developed for a shallow regolith involves distributing observatory loads onto a firm substrate under the regolith by means of end-bearing piles. For a deep regolith we propose one foot diameter footings augured into the regolith. An optimization scheme was developed to use in defining a reasonable regolith thickness for which the deep regolith foundation should be used rather than using the end-bearing piles proposed for the shallow regolith.

202. CORE SAMPLE DEPTH RELATIONSHIPS: APOLLO 14 AND 15

Stewart W. Johnson, Lt Col, USAF 9p Lab Sponsor: NASA
W. D. Carrier, III, L. H. Carrasco, Ralf Schmidt

Proceedings of the Third Lunar Science Conference, Vol. 3, pp 3213-3221, MIT Press, Cambridge, Mass., 1972

The depth relationships for the Apollo 14 and 15 core tubes and the Apollo 15 drill core are presented, as determined from laboratory simulation studies. Sample at a depth of 40 cm in the Apollo 14 double core tube (virtually the same as the Apollo 12 tubes) represents material from a depth of approximately 58 cm in the lunar surfaces. The new design of the Apollo 15 core tube results in much less sample disturbance and the depth relationship is practically one-to-one, with sample recovery approaching 100%. The depth relationship for the drill core is also probably close to one-to-one, and its recovery ratio was also 100%. The in situ bulk density at the Apollo 14 core tube sites was 1.4^5 to 1.6 g/cm^3. The Apollo 15 densities ranged from 1.36 to 1.93 g/cm^3.

203. A SIMPLE BUT COMPLETE SOLUTION FOR THE STEP RESPONSE OF A SEMI-INFINITE, CIRCULAR FLUID TRANSMISSION LINE

James T. Karam, Jr., Capt, USAF 2p Lab Sponsor: AFFDL

Journal of Basic Engineering, Transactions, American Society of Mechanical Engineers, Series D, Vol 94, No. 2, pp 455-456, June 1972

Presently, the only accurate solutions for the step response of a semi-infinite, circular fluid transmission line result from involved, time consuming, numerical finite series of integration techniques. None of these solutions is practically suitable for either a rapid manual prediction for an arbitrary fluid line (liquid or gas), or for extension of the semi-infinite line results to the more meaningful problem of a finite line with arbitrary inputs. In the frequency domain (sinusoidal signals), a complete, verified solution exists and theoretically could be transformed into the time domain. This was the scheme used by Brown and Nelson for

liquid lines, but it required the numerical techniques referred to above and, in their own words, was a "very complex and tricky business." However, simpler solutions for most operating regimes also exist in the frequency domain. These simple frequency domain solutions were transformed into the time domain and provided the basis for a simple solution for the step response.

204. ESTIMATION OF PARAMETERS IN LIFE TESTING AND RELATED TOPICS

Albert H. Moore 85p Lab Sponsor: ARL

University Microfilms, Class A, A-416 394, September 1972

The results of the thesis are presented in four parts: (1) Admissible, minimax, and equivariant estimators are obtained for random and Type I censored samples from a generalized life testing model, the exponential, Weibull, Rayleigh, exponential model for special sampling procedures, gamma, Type II asymptotic distribution of largest values, Pareto and a limited distribution. (2) The problems of estimation of parameters and the reliability function, from a Bayesian viewpoint is considered for the above life testing models. (3) A new approach is made to the estimation of the variance of normal distribution with unknown scale parameter, to the estimation of the scale parameter of the exponential with unknown location parameter. A new estimator is derived fro the mean of a multivariate normal density with ($n > 2$). (4) Problems are considered where the classical best unbiased estimator is admissible and it is shown that if enough information is available to bound the parameter that the classical uniformity minimum variance estimator is inadmissible.

205. PERSONAL VALUE SYSTEMS OF MANAGERS AND THE OPERATIVE GOALS OF THE ORGANIZATION: AN IN-DEPTH ANALYSIS OF ONE FIRM

Roger T. Manley, Maj, USAF 374p Lab Sponsor: AFIT

Air Force Institute of Technology, School of Engineering Technical Report, (AFIT TR 72-5), May 1972

This study had as its objective the identification and hierarchical ranking of the operative goals of a large, established firm subject to relatively close government regulation, and recognized as possessing strong commitments to both the profit and public service motives. Goals were identified through interviews with managers at all organizational levels, review of company documentation (including completed appraisal reports), and observation of normal operations. Once identified, the goals were incorporated into a questionnaire which included Prof George W. England's Personal Values Questionnaire. Each respondent was classified into one of four possible orientations on the basis of his/her responses to the personal values section, and this information was used to determine behavioral relevance scores for the goals. The organization studied was New York Telephone. Managers were, for the most part, randomly selected from the New York City, suburban, and rural areas, and ranged in organizational level from foreman to vice president. Of the 611 questionnaires distributed, 360 were returned with useable data. The study was hampered throughout by a strike of the Communications Workers of America against the company. The dispute between Plant Department craftsmen and New York Telephone was the longest in the history of American Telephone and Telegraph.

206. PERSONAL VALUE SYSTEMS OF MANAGERS AND THE OPERATIVE GOALS OF THE ORGANIZATION: AN IN-DEPTH ANALYSIS OF ONE FIRM

Thomas R. Manley, Maj, USAF 374p Lab Sponsor: AFIT

PhD Dissertation submitted to Rensselaer Polytechnic Institute, Troy, New York, March 1973

This paper reports on a study conducted with New York Telephone during 1971-1972. It presents a rationale for the use of the personal value system of managers in arriving at a hierarchical ranking of (operative) organizational goals. It presents a review of the literature dealing with values and with organizational goals and a discussion of the basic study. In the study 360 managers responded to the questionnaire with useable data. From their responses some 66 personal value concepts (previously used by Prof George W. England of the University of Minnesota) were ranked hierarchically, as were 27 operative organizational goals. The operative goals were identified through the observation of managers in their work environment, through a review of company documentation (including the firm's management control plan and completed appraisal reports), and through numerous interviews. Included in the sample were 117 woman managers. Among the findings were that managers at the lower levels appeared to place greatest importance on service, employee welfare, and profits in that order. In the chi square analyses, 148 significant differences were noted at the 0.05 level of significance in the valuation of the value concepts, and 81 differences were noted in the valuation of the goals. Although the goals of the officers and managers of the company were cogruent in the area of service, managers evidenced much less concern over profit than did company officers. Woman managers appeared to internalize the values and goals of the organization to a much greater extent than did their male counterparts.

207. PERSONAL VALUE SYSTEMS OF MANAGERS AND THE OPERATIVE GOALS OF THE ORGANIZATION

Thomas R. Manley, Maj, USAF 12p Lab Sponsor: AFIT

Proceedings, American Institute for Decision Sciences, 1972 Midwest Conference, pp H-15 - H-20, Southwestern Publishing Co., Cinn, Ohio, April 72

This paper reports on a methodology, utilizing the personal value systems of managers, for determining what goals managers throughout the organization are attempting to influence. Distinction is made between "official goals" (those organizational goals professed by officials in the organization) and "operative goals" (those organizational goals which members actually try to achieve.) This paper also relates the findings, and the implication of the findings, of a study performed with New York Telephone in 1971-1972 utilizing this methodology.

208. AN EXTENDED COMPUTER EXPERIMENT EMPLOYING SIMULATED RELAY CONTROL SYSTEMS

Donald McLean, Sqn Ldr, RAF
Gareth H. Rees

19p

Lab Sponsor: RADC

International Journal of Electrical Engineering Education, Vol 10, No. 1, pp 21-39, February 1972

This paper presents an extended analog computer experiment to investigate the properties of simulated relay control systems. Linear and optimal non-linear switching characteristics are investigated and the effects of non-ideal characteristics are considered. The final section of the paper is concerned with the investigation of the application of optimal relay controllers to a simple linear plant and with a study of the resulting performance of the various optimal schemes.

209. MATRIX ANALYSIS OF LOCAL INSTABILITY IN PLATES, STIFFENED PANELS AND COLUMNS

Janusz S. Przemieniecki

8p

Lab Sponsor: AFFDL

International Journal for Numerical Methods in Engineering, Vol 5, No. 2, pp 209-216, November-December 1972

A displacement method of matrix analysis for local instability of plates, stiffened panels and thin-walled columns is presented. The analysis is applicable to stiffened panels and columns for which the cross-section is made up of thin flat plates. For these cases it may be assumed that during buckling deformation no flat component of the cross-section is translated in its own plane and the edge lines at the junctions between flats remain fixed in space. The analysis leads to the standard eigenvalue equation from which the buckling stress can be determined. The elastic and geometrical stiffness matrices derived for this analysis depend on the wavelength of the buckled pattern and this dependence is of a simple form since all coefficients in the resulting stiffness matrices contain the buckling wavelength only as a common factor allowing for considerable simplification in any numerical computations. With this new formulation of local instability analysis very few elements are required to obtain high accuracy for the buckling stress. Several examples illustrating typical applications of this new method have been included.

210. FINITE ELEMENT STRUCTURAL ANALYSIS OF LOCAL INSTABILITY

Janusz S. Przemieniecki

9p

Lab Sponsor: AFFDL

American Institute of Aeronautics and Astronautics Paper No. 72-354, AIAA, New York, New York, April 1972

A finite element analysis is presented for predicting local buckling stresses in plates, stiffened panels, and thin-walled columns for which the cross-section is made up of thin flat plates. The analysis leads to the formulation of the elastic and geometrical stiffness matrices appearing in an eigenvalue equation used to determine the buckling stress. The stiffness matrices are derived from the exact sinusoidal lengthwise variation of displacements. The resulting sinusoidal stiffness matrices depend on the wavelength of the buckled pattern but this dependence is of very simple form since all stiffness coefficients contain the buckling wavelength as a common factor. Examples are given to illustrate application of the method to several typical aircraft structural components.

211. OUTPATIENT SCHEDULING - A SIMULATION APPROACH

Ronald J. Quayle, Maj, USAF 4p Lab Sponsor: MED CTR
David L. Belden, LtCol, USAF, Ronald K. Hall, Capt, USAF

Proceedings, American Institute for Decision Sciences, 1972 Midwest Conference, pp J-5 - J-8, Southwestern Publishing Co., Cinn., Ohio, April 72

Obstetric outpatients, attending the prenatal clinic at the Wright-Patterson AFB Medical Center, were frequently required to wait in excess of one hour to see a doctor even through their consultations are scheduled by appointments. Two causes that contribute to this waiting time are the uncertainty as to the number of doctors that will be available for the clinic and the attempt to eliminate doctor idle time. A computer simulation model was developed to enable experimentation with twelve different appointment systems. The simulation model takes into account four random occurrences (patient arrival time, consultation time, arrival of walk-in patients and number of doctors available) which characterize this particular clinic. The appointment system, recommended for immediate implementation, schedules 10 patients for the first appointment and 5 patients each 10 minute interval thereafter. This recommendation is based on a normally distributed patient arrival time, about a mean of 11.14 minutes before the appointment time, a gamma distributed consultation time with a mean of 6.86 minutes, a 40 minute mean inter-arrival time for walk-in patients and from one to six doctors available. The resulting average patient waiting time and average doctor idle time was 17.73 minutes and 2.82 minutes, respectively.

212. STOCHASTIC MODELING OF HUMAN PERFORMANCE EFFECTIVENESS FUNCTIONS

Thaddeus L. Regulinski 10p Lab Sponsor: AFHRL

Annals of Assurance Sciences, IEEE Cat #72CHO 577-TR, pp 407-416, IEEE, New York, New York, January 1972

Human performance effectiveness functions Reliability and Correctability are mathematically modelled in stochastic, time-continuous domain from error data experimentally generated by tracking and vigilance tasks. The probability density functions governing the random variables time-to-error, and time-to-error-correction are isolated using the Kolmogorov-Smirnov test and the Likelihood Ratio test. A number of task performance predictions are reported based on the Weibull, and Log-normal density functions.

213. STOCHASTIC MODELING OF HUMAN PERFORMANCE IN CYBERNETIC SYSTEM

Thaddeus L. Regulinski 19p Lab Sponsor: AFHRL

Proceedings of World Organization of General Systems & Cybernetics, pp 216-255, Blackburn College of Tech. Press, Blackburn BB2 1LH,Laneshire,UK,Sep 72

The object of the paper is the formulation and quantification of a generalized time-continuous stochastic function useful as a metric in cybernetic systems. From data generated by two-axis compensatory type tracking task simulating aircraft flight perturbed by random

disturbance, controllability function $y_h(\tau)$ was formulated and quantified by $y_h(\tau) = \int_\tau^\infty f(\tau)d\tau$ where τ is the ration of time spent on control to time spent out of control, and $f(\tau)$ is the probability density function governing the random variable τ. Based on experimental results, the lognormal density was isolated as the model for the controllability function. Data stationarity was tested and accepted at the α=0.10 level of significance, however ergodicity was rejected.

214. DAMPING ADDITIONS FOR PLATES USING CONSTRAINED VISCOELASTIC LAYERS

Peter J. Torvik, D. Z. Strickland 7p Lab Sponsor: AFFDL

Journal of the Acoustical Society of America, 51:4, pp 985-991, March 1972

An analysis is given for a damping addition employing several thin viscoelastic sheets and thin metallic layers. The damping layers are alternated with the constraining layers, which are segmented and are not anchored to the base plate. The effectiveness of such additions in increasing the damping of thin simply supported square plates is evaluated and methods for optimizing the design are considered. An experimental investigation of the effectiveness of such damping additions is also reported. Additions weighing a few percent of the weight of the base plate were found to produce substantial increases in the damping of the system. A nonoptimal design was found to produce less, but still substantial, damping.

215. A PRACTICAL APPROACH TO LASER HEATING CALCULATIONS

Peter J. Torvik 8p Lab Sponsor: AFWL

Laser Division Digest, Air Force Weapons Laboratory (AFWL)-LDR-72-1, pp 136-143, June 1972

A numerical method for determining the transient temperature distribution in solid slabs due to high intensity lasers is given. Effects of radial conduction, melting and vaporization are included. The method is based on a heat balance on each of a large number of subdivisions of the heated object. Applications to the prediction of rear surface temperatures of thin sheets and the melt-through times for slabs are given. Extensive results for magnesium are given. It is demonstrated from the numerical calculations that the melt through time is a function of both power and intensity, with the condition for one dimensional heating (axial) being a critical value of the beam power divided by the sample thickness.

216. A METHOD FOR IMPROVING THE ESTIMATION OF MEMBRANE FREQUENCIES

Peter J. Torvik 10p Lab Sponsor: AFFDL
Franklin E. Eastep, Maj, USAF

Journal of Sound and Vibration, 21:3, pp 285-294, April 1972

A method for obtaining approximations of the natural frequencies of membranes is developed. An approximate expression for the radius of the bounding curve is first written as a truncated Fourier series. The deflection, which is written as a super-position of the modes of the circular membrane, is forced to vanish (approximately) on the approximated boundary. This generates a system of linear homogeneous equations, the unknowns in which are the amplitudes of the modes of the circle. Equating the determinant of

coefficients to zero yields an equation from which the approximate frequencies may be found. It is shown that the first-order approximation obtained through this procedure is identical to a method by Rayleigh. Approximate frequencies of the first several modes of membranes in the shapes of a square, an ellipse, and the limacon of Pascal are then determined as demonstrations of the new second-order approximation. The approximations of the first three natural frequencies of the ellipse were found to be in error by less than 5% for eccentricities of 0.8 or less, and the approximations of the first four frequencies of the square were found to be in error by less than 3%.

217. INFLUENCE OF A SURFACE MASS DISTRIBUTION ON THE MOTION OF BARS

Peter J. Torvik 9p Lab Sponsor: AFFDL
James E. Wade, Maj, USAF

Journal of the Acoustical Society of America, 52:3:2, pp 935-943, September 1972

A method is developed for determining the modes of propagation for progressive harmonic waves in infinite rectangular elastic bars. The faces of the bar are covered with a distributed mass of negligible stiffness, as found with a layer of insulation or a damping treatment. An approximate solution is obtained by expanding the displacements as a power series in the thickness coordinates and retaining only terms through first order. The D'Alembert force due to the acceleration of the mass produces surface tractions which influence the motion and introduce coupling between the longitudinal, torsional, and flexural motions. If equal mass distributions are applied over opposite faces, the motions are qualitatively similar to the motions of a free bar. If unequal masses are added to opposite faces, the motions are more coupled than those of a free bar. The addition of mass to two adjacent faces leads to a yet higher degree of coupling.

218. IMPACT CRATER FORMATION AT INTERMEDIATE VELOCITIES

Peter J. Torvik 7p Lab Sponsor: AFML
N. C. Byrnside, Capt, USAF, H. F. Swift

Journal of Basic Engineering; Transactions, American Society of Mechanical Engineers, 94.D-2, pp 394-400, June 1972

The influence of projectile strength on cratering was investigated for projectiles of aluminum alloys impacting semi-infinite aluminum targets over the velocity range of 1 km/sec to 5.0 km/sec. The experimental results showed that crater diameters were not significantly influenced by varying projectile strength. The crater depths were found to vary appreciably with strength at lower velocities but to become virtually the same at 3.5 km/sec for the series of projectile alloys investigated. A simple dynamic model for cratering was developed and compared with the experimental results of this study and other experimental results at higher velocities. These comparisons showed that the model provided predictions of crater diameter which were within 8% for the experimental results of this study and within 13% for the hypervelocity data. Crater depth predictions showed good agreement with the experimental results of this study for projectiles having greater yield strength than the target material. The predictions of depth as a function of velocity showed qualitative agreement with the hypervelocity data.

219. A SIMPLE MODEL FOR THE SHOCK WAVE INDUCED BY HIGH-SPEED IMPACT

Peter J. Torvik 6p Lab Sponsor: AFML
Ronald J. F. Prater, Maj, USAF

Journal of Spacecraft and Rockets, 9:1, pp 13-18, January 1972

The classical self-similar solution of the point source blast wave problem and its adaption to impacts in solids are discussed. The derivation of a previously developed "varying-γ" model is reviewed and the results are compared with new, direct experimental measurements for shock decay in 1100-o-aluminum. A new "varying energy" model is developed and described. This modified model allows both the γ and energy in the blast wave solution to vary in an attempt to account for the fundamentally non-similar behavior of the solid material more accurately. An improved match of the shock Hugoniot for the solid material is also employed. Results indicate considerably improved agreement with experiment when one free parameter (which can be determined from one experimental point) is properly chosen.

220. ELASTIC WAVE PROPAGATION IN FILAMENTARY COMPOSITE MATERIALS

Peter J. Torvik 17p Lab Sponsor: AFML
R. A. Bartholomew, Maj, USAF

International Journal of Solids and Structures, 8: pp 1389-1405, Dec 1972

An approximate first order theory for elastic wave propagation in uni-directional, filamentary composite materials is developed. Included are stress equations of motion, boundary conditions and constitutive relations. For waves propagating parallel to the fiber orientation in an extended medium, the motion separates into three distinct types: longitudinal, flexural and torsional. All motions are dispersive and sensitive to changes in relative material stiffness and geometry. For propagation perpendicular to the fiber orientation, the motion is dispersive and the frequency spectra show stopping bands typical of periodic media.

221. A SIMULATION ANALYSIS OF THE ECONOMIC CONSEQUENCES OF ESTABLISHING MULTI-MODAL TRANSPORTATION COMPANIES

Robert S. Tripp, Capt, USAF 243p Lab Sponsor: HQ USAF

Air Force Institute of Technology Technical Report, AFIT-TR-72-6, Dec 1972

This study is concerned with the examination of the economic consequences of establishing multi-modal transportation companies. More specifically, the purpose of this research is to: (1) examine the economic impact various combinations of parameters or test factors have on a transportation company formed from single model carriers, and (2) determine "on the average" which organizational form, i.e., transportation company versus single modal carriers, is economically superior. In order to accomplish this goal, a simulation model was developed which made the comparison of a transportation company with single modal carriers possible. Within this framework, the economic performance of the two organizational approaches was contrasted for both TL/CL and LTL movements. The test factors which were selected for analysis are: (1) the operating ratios of the forming modes (truck and rail), (2) the load factor of the forming modes, (3) the amount of available capacity, (4) and the level of shippers' logistics constraints. The

performance measures which were selected to describe the economic impact of operating a transportation system under the two different organizational approaches are: (1) the expected contribution (to fixed and/or common costs including profit margin), of the carriers, (2) the actual contribution of the carriers, (3) the total price paid for transportation by shippers, and the amount of traffic moved by (4) truck, (5) piggyback, and (6) rail under each organizational approach.

222. DESIGN CONSIDERATIONS FOR PICOSECOND PULSE LASERS

Hugo Weichel, Maj, USAF 6p Lab Sponsor: AFIT

Proceedings-Electro Optical Systems Design Conference, pp 151-156, Industrial & Scientific Conference Mgmt Inc., Chicago, Illinois, 1972

Picosecond pulses from Nd:glass lasers have been studied for several years, Yet, their use and application is still limited. This is primarily due to the unreliable nature of the laser to mode-lock in a consistent manner. To improve upon the reliability and reproducibility of these lasers it is necessary that one understands the origin and evolution of the picosecond pulse. Since the pulse originates in the initial noise of the spontaneous radiation from the laser medium its evolution is governed by the gain medium and the saturable absorver which causes the initial intensity fluctuation of shortest duration to lose the smallest amount of energy. For certain well controlled experimental conditions only one of these fluctuations will bleach the saturable absorber and develop into a pulse of duration equal to the inverse of its bandwidth. Our study has shown that the further evolution and eventual collapse of this pulse is primarily affected by the specific experimental apparatus. We have studied how the pump power, mirror alignment, and saturable dye concentration and location in the cavity affect the reliability and found that these parameters must be critically controlled. Furthermore, by paying much attention to what have until recently been thought of as minor details in the design of the laser head such as mounting of the flashlamps, cavity reflectors and laser rod, we have now achieved virtually 100% reliability and remarkable reproducibility. Experimental conditions affecting component lifetimes are also described. By controlling the operating procedures and laser environment we have achieved exceptionally long component lifetimes.

223. HEAT TRANSFER POTENTIAL OF LIQUID-GAS SPRAY FLOWS

Harold E. Wright 14p Lab Sponsor: ARL
William C. Elrod, Max G. Scherberg

Progress in Heat and Mass Transfer, Vol. 6, pp 739-752, Pergamon Press Inc., Elmsford, New Jersey, New Jersey, November 1972

The heat transfer characteristics for forced convection of a two-phase air-water spray flow over three geometric shapes under conditions comparable to the upstream stages of a heat exchanger bank were investigated. With a ratio of water spray to air mass flow less than 0.1, the average heat transfer is increased at least an order of magnitude in comparison to that for air flow alone. The heat transfer amplification is limited to that region of the geometric shape covered by a liquid film and a very large increase is obtained at the forward stagnation

point. Data presented show the enhancement of heat transfer from a right circular cylinder by the addition of water spray to the air stream. In addition, improvements of heat transfer obtained with the two-phase flow by considering an elliptical cylinder and an extended bluff body which permit an increase in the percentage of total surface area covered by a liquid film are presented. The interaction of the liquid droplets with the liquid film on the heated surface was investigated to gain a more complete understanding of the heat transfer amplification process.

224. CONSTANT TEMPERATURE ANEMOMETER MEASUREMENTS IN HOSTILE LIQUIDS

Harold E. Wright 5p Lab Sponsor: ASD
William C. Elrod, Stephen Zakanycz

Leicester University Press, Volume 1, pp 100-104, Leicester, England, April 1972

Investigation of fluid motion using a constant temperature anemometer system employing hot films to measure mean velocity in a 20% solution of sodium chloride is reported. A laser velocimeter was also employed to check the mean velocity in the saline solution. The liquid flow measurements with a hot-film constant temperature anemometer and laser velocimeter agree well with Shercliff's two-dimensional, incompressible flow of a conducting fluid in a magnetic field.

PART V

INDEX OF SPONSORING ORGANIZATIONS

AFAL - *Air Force Avionics Laboratory*
AFAPL - *Air Force Aero-Propulsion Laboratory*
AFATL - *Air Force Armament Test Laboratory*
AFCRL - *Air Force Cambridge Research Laboratory*
AFFDL - *Air Force Flight Dynamics Laboratory*
AFHRL - *Air Force Human Resources Laboratory*
AFIT - *Air Force Institute of Technology*
AFLC - *Air Force Logistics Command*
AFML - *Air Force Materials Laboratory*
AFRPL - *Air Force Rocket Propulsion Laboratory*
AFSA - *Assistant Chief of Staff (Studies & Analysis)*
AFSC - *Air Force Systems Command*
AFSL - *Assistant Chief of Staff (Systems & Logistics)*
AFWL - *Air Force Weapons Laboratory*
AMRL - *Aerospace Medical Research Laboratory*
ARL - *Aerospace Research Laboratories*
ASD - *Aeronautical Systems Division*
CES - *Civil Engineering School - AFIT*
FTD - *Foreign Technology Division*
HQ USAF- *Headquarters, United States Air Force*
MAC - *Military Airlift Command*
MEDCEN - *Medical Center - Wright-Patterson AFB Hospital*
NASA - *National Aeronautics & Space Administration*
NUSL - *Naval Underwater Sound Laboratory*
RADC - *Rome Air Development Center*
SAMSO - *Space and Missile Systems Organization*
TAC - *Tactical Airlift Command*
TAW - *Tactical Air Wing*
USAMC - *United States Army Missile Command*
USN - *United States Navy*

PART VI

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13. ABSTRACT

This report contains abstracts of Master of Science Theses, Doctoral Dissertations, and faculty publications completed during the 1972 calender year at the School of Engineering, Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio 45433.

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